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Three Essays On Bond Trading

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THREE ESSAYS ON BOND TRADING

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ABSTRACT

In Part 1, we study the impact of bond exchange listing in the US publicly traded corporate bond market. Overall, we find that listed corporate bonds have lower bid-ask spreads than unlisted corporate bonds. We specifically show that listed bond spreads are $0.14 lower than unlisted bond spreads. We find that execution venue matters for listed bonds, and that listed bond trades that execute on the NYSE have higher trading costs than listed bond trades that execute off-NYSE. We show that listed bonds are more volatile than unlisted bonds. Lastly, we study bond trading around earnings announcements. We find no evidence that listing influences institutional (or large trading) activity in bonds. In Part 2, we study municipal bond market activity before, during, and after natural disasters (tornados, wildfires, and hurricanes/tropical storms). Using a sample of municipal bond trades from 2010 to 2013, we find that natural disasters influence municipal bond trading. Specifically, we show that spreads are lower on both tornado and wildfire event days and during following five trading days than during the preceding five trading days. While we do not document a relation between hurricane events and spreads, we show that spreads fall during the five days following the hurricane compared to the five trading days before the event. Generally, we document an increase in dollar volume in the five trading days following all three types of natural disasters. We also determine that linkages exist between the bonds affected by natural disasters and related bonds. In Part 3, we study municipal bond trading activity before, during, and after announcements of government officials' misconduct. Using a sample of over 39,000,000 trades in nearly 500,000 bonds, we find that spreads are higher on news, indictment announcement, and trial verdict announcement days than other trading days. Spreads remain elevated through the five trading days following the announcement. We also find that large bond trades account for the majority of price discovery on event days. Overall, our results establish a link between government officials, their misconduct, and municipal bond markets.

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PART 1: THE VALUE OF BOND LISTING

INTRODUCTION

In the United States bond market, firms can list publicly traded bonds on the New York Stock Exchange or publicly traded bonds can be unlisted with no exchange affiliation. The trades that bond dealers report to the Trade Reporting and Compliance Engine (TRACE) execute on trading platforms across the United States, but do not include trades in listed bonds that execute on the New York Stock Exchange. The NYSE Automated Bond System operates as an electronic limit order book that executes trades in listed bonds on a price-time priority basis. Listed bond trades can execute on the NYSE or any of the TRACE bond trading platforms, while unlisted bonds can trade only on TRACE bond trading platforms.

Previous research documents two main advantages for securities listing on a national exchange: investor recognition and improved liquidity. Merton (1987) uses the capital asset pricing model to show theoretically that listing on an exchange is one way the firm can increase investor recognition, and Kadlec and McConnell (1994) show empirically that listing on the NYSE leads to a 27% increase in institutional shareholders for the firm. Research also documents a market quality advantage for NYSE stocks and for NYSE trades. For example, Huang and Stoll (1996) and Bessembinder and Kaufman (1997) compare NYSE and NASDAQ listed stocks using data from the early 1990s, when markets were more consolidated and listing potentially had a different value than it may in today's fragmented trading environment. Both Huang and Stoll and Bessembinder and Kaufman find that a sample of NYSE stocks has lower trading costs than a matched sample of NASDAQ stocks. Bennett and Wei (2006) find that lower trading costs occur for firms that switch their listing exchange from NASDAQ to the

NYSE. The above mentioned research focuses only on equity markets. Analyzing the benefits of listing using bonds provides valuable research contributions for multiple reasons.

First, most of the research on listing focuses on highly liquid assets. Bonds are illiquid, with the average corporate bond trading just over two times per day (Edwards, Harris, and Piwowar, 2007). Bennet and Wei (2006) show that listing on the NYSE is particularly valuable for illiquid stocks. However, even the most liquid bonds will likely be less liquid than illiquid stocks, thus leaving unanswered questions about the importance of listing for illiquid assets. Bonds are more expensive to trade than equities, both for institutions and individual traders, so documenting differences in trading costs between listed and unlisted bonds could be beneficial for bond traders. Determining what market quality advantages, if any, listing provides to bond traders sheds light on why firms choose to list their publicly traded debt.

Second, it is possible that listing a bond serves as a signal or stamp of approval to investors, much like paying dividends and beating earnings expectations can serve as a signal to stakeholders (Bhattacharya, 1979; Nissim and Ziv, 2001; and Fuller and Goldstein, 2011). Bonds may be listed on one venue – the NYSE— whereas firms can choose from multiple exchanges for equity listing (for example, the NYSE, NASDAQ, or AMEX). Choosing to list a bond may provide information to the market as to the quality of the bond. The bond market as a whole is less informationally efficient than the stock market (Kwan, 1996; Downing, Underwood, and Xing, 2009), and traders (both institutions and retail) may be able to better garner information based on a bond's listing status. Third, the bond market is economically large. According to Ederington and Yang (2013), US firms issued $6.6 trillion in corporate bonds from 2005 to 2011, compared to just $1.3 trillion in common stock offerings over the same time period.

RELATED LITERATURE

Merton (1987) provides theoretical reasoning for the firm's decision to list on a national exchange. Merton utilizes the original capital asset pricing model in his theory of listing, but makes one change to the model's assumptions. Merton relaxes the assumption that all investors share equal information sets and develops a model in which expected returns decrease with the size of the firm's investor base. He shows an increase in the investor base (i.e., an increase in investor recognition) leads to lower expected returns and a higher market value for the firm. He goes on to detail that one way a firm increases its investor base is to list on a national exchange. Sanger and McConnell (1986) detail that listing provides a liquidity advantage, and also that an organized exchange can provide investors with a better quality of trading. Baruch and Saar (2009) propose that, in addition to investor recognition and liquidity, firm commonality plays a role in the firm's decision to list on an exchange. Specifically, Baruch and Saar show that a stock is more liquid when it is listed on a market along with similar securities; the liquidity advantage arises because market makers are able to ascertain information about the firm using the order flow of other stocks listed on the exchange, thus improving the efficiency of prices.

Many of the studies that show a market quality or liquidity improvement for listing study a time when markets were more consolidated, and a time when the home listing exchange executed the majority of trades in listed securities. For example, Huang and Stoll (1996) compare trading costs of large capitalization NASDAQ stocks to the trading costs of a matched sample of NYSE stocks using trade data from 1991, a time when markets were consolidated. The authors find that NYSE stocks have lower trading costs than the matched sample of

NASDAQ stocks. Bessembinder and Kaufman (1997) expand the work by Huang and Stoll and compare the execution costs of NASDAQ and NYSE listed stocks using small, medium, and large capitalization stocks and find similar results. However, the study again uses a time period from the early 1990s (1994) when markets were more consolidated, and the advantages of the listing exchange were perhaps different.

After markets began to experience increased fragmentation in trading, listing continued to have value.   Bessembinder (2003) studies a sample of NYSE stocks using trade data from June 2000 and makes comparison among seven markets that compete for order flow in large capitalization NYSE stocks. Bessembinder finds the NYSE is the most competitive market for NYSE listed stocks, despite the fragmented trading opportunities. Bennett and Wei (2006) examine a sample of 39 firms that switch from NASDAQ to the NYSE in 2002 and 2003. Stocks have lower quoted spreads, effective spreads, and price volatility following the switch to the NYSE. In addition, price efficiency improves after the firms switch to the NYSE. Bennet and Wei use Dash-5 data to show the improvement in market quality is driven by a reduction in order flow fragmentation. Empirically, there is strong support for NYSE equity listing and NYSE equity trades providing investors with better market quality.

The majority of research that relates to the advantages of listing on a national exchange focuses on equities and does not reach a definitive conclusion as to whether an exchange environment or a dealer environment is better. Now that trading in many securities markets is fragmented and listing bonds means simply that bonds can trade on the NYSE as well as other venues, is listing valuable? If so, is it valuable because only listed bonds can trade on the NYSE? We seek to determine the value of listing for bonds.

HYPOTHESES

First, we focus on the differences in listed and unlisted bonds. Previous work shows that bonds are more expensive to trade than equities.[1] It is not clear, however, if listed bonds offer better execution costs than unlisted bonds. Empirically, Huang and Stoll (1996) and Bennet and Wei (2006) show trading costs are lower for NYSE listed stocks. In addition, Bessembinder and Kaufman (1997) detail that trading costs are higher for off-NYSE stock trades in NYSE stocks. We form the following two hypotheses:

H1: Listed bonds have lower spreads than unlisted bonds.

H2: Listed bond transactions that execute on the NYSE have lower trading costs than listed bond trades that execute off the NYSE.

Second, we focus on price efficiency. Listing also affects price efficiency, as is indicated in Heidle and Huang (2002) and Baruch and Saar (2009). Three measures of price efficiency include return volatility, the variance ratio (O'Hara and Ye, 2011), and price volatility (Downing and Zhang, 2004). Bennet and Wei (2006) show empirically that volatility falls for stocks that switch their listing to the NYSE, and Baruch and Saar (2009) detail that a firm's choice to list on an exchange with similar firms can lead to more efficient information processing by market makers. We present the following hypothesis:

H3: Price efficiency is positively related to a bond being listed.

[1] See Goldstein, Hotchkiss, and Sirri (2007), Bessembinder, Maxwell, and Venkataraman (2006), Harris and Piwowar (2006), and Edwards, Harris, and Piwowar (2007) for further evidence.

Third, we focus on the relation between listing and a firm's investor base. Theoretical work by Merton (1987) and empirical work by Kadlec and McConnell (1994) indicate that listing serves as a way to expand a firm's investor base. Specifically, Kadlec and McConnell (1994) show that NYSE listing leads to a 27% increase in the number of institutional shareholders a firm has on record. However, the question of whether or not listing leads to more institutional trading in bonds remains. Bessembinder, Kahle, Maxwell, and Xu (2009) details that institutions have a prevalent role in the bond market. Ronen and Zhou (2013) detail that trade size is a reliable way to measure institutional trading in bonds and show that trades greater than $500,000 in size are institutional trades.[2] We question if bond listing matters for institutional trading activity and form the following hypothesis:

H4: Listed bonds have a larger amount of institutional trading than unlisted bonds.

[2] We follow Ronen and Zhou (2013) and classify bond trades as institutional if the trade value exceeds $500,000. Earlier bond papers, such as Edwards, Harris, and Piwowar (2007) classify trades as institutional if the trade size is greater than $100,000. In preliminary work, we use both trade sizes, $100,000 and $500,000, in all tests, to label institutional trades. We find that the results are qualitatively similar, and therefore we follow the more recent Ronen and Zhou paper.

SAMPLE AND DATA

We use bond transaction level data for the year 2013. Our bond trade data is from two sources: TRACE and the NYSE. We follow Bessembinder, Maxwell, and Venkataraman (2006) in making data deletions. We delete trades flagged as cancelled (135,437 observations), corrected (136,572 observations), reported after-market hours (48,170 observations), reported late (241,588 observations), and after-market trades reported late (8,132 observations). We delete 1,678,597 trades in bonds issued by private companies, and we also delete 754 trades with missing CUSIP identification. We delete any bond trading at less than 25% of par (15,662). We require the bond to trade at least ten times during our sample period (Edwards, Harris, and Piwowar, 2007). We obtain daily shares outstanding and daily stock prices from CRSP to calculate the firm's daily market capitalization.

In our study, we make comparisons between two types of bonds (listed and unlisted), and also between different trading venues (the NYSE and other bond trading platforms). The NYSE bond market and TRACE have different trading hours. The NYSE offers three bond trading sessions during the day: 4:00 am - 9:30 am EST (Early Trading); 9:30 am – 4:00 pm EST (Core Trading); and 4:00 pm – 8:00 pm EST (Late Trading). TRACE reporting is allowed from 8:00 am – 6:30 pm EST. To provide a clean comparison, we use an overlapping time between TRACE reporting hours and NYSE trading hours. As a result, we use trades that execute between 8:00 am to 6:30 pm EST. Following all data deletions, we have 6,841,030 bond trades in 12,633 bonds for the 2013 calendar year (our full sample period).

Appendix 1 provides a general overview of our sample. For the sample of trades, 73.3% involve an investment grade bond. 81.53% of trades involve a bond with less than ten years to maturity. Top bonds make up the majority of trades, accounting for 52.12% of all transactions. In regards to trade size, trades greater than $25,000 account for 47.36% of trades, while trades greater than $500,000 (institutional trades) account for only 13.44% of trades. Substantially more trades occur in bonds priced above par value (76.23%) than bonds priced below par value (23.13%).

Appendix 1 also shows summary statistics for listed and unlisted bonds. Unlisted bond trades are split fairly evenly between investment grade and high yield bonds, while listed bond trades are dominated by investment grade bonds. Investment grade bonds account for 81.07% of listed bond trades, while high yield bonds account for just 18.93% of listed bond trades. Roughly 40% of bond trading in both listed and unlisted bonds occurs in bonds with less than five years to maturity, while over 80% of trades in both listed and unlisted bonds occur in bonds with less than ten years to maturity. The percentage of institutional trades (trades greater than $500,000) is 16.22% for unlisted bonds, while 12.30% for listed bonds. Trades greater than $1,000,000 make up similar portions of listed and unlisted bonds (6.54% compared to 5.08%). For both listed and unlisted bond trades, over 70% of trades involve a bond priced above its par value.

Appendix 2 provides summary statistics for the full sample of bonds. Panel A includes all bonds in the sample. The sample includes 12,633 bonds that trade during the 2013 calendar year. On average, the bonds in the sample trade at 105.49% of par. The average bid-ask spread for the full sample of bonds is $1.34. The average bond trades 4.73 times each day and transacts over $1,500,000 in daily dollar volume with an average trade size of roughly $380,000. Panel B details the summary statistics for listed bonds, and Panel C details the summary statistics for unlisted bonds. The average listed bond trades at 109.44% of par, while the average unlisted bond trades at 102.73% of par. Overall, listed bonds appear to trade more times than unlisted bonds. The average listed bond trades nearly six times each day, while the average unlisted bond trades about four times each day. Listed bonds have an average daily dollar volume of over $2,000,000, while unlisted bonds execute an average of $1,000,000 in daily dollar volume. Listed bonds appear to have lower spreads than unlisted bonds. Listed bonds have an average spread of $1.17, while unlisted bonds have an average spread of $1.45. Volatility appears similar between the listed and unlisted bonds. However, we do not test for differences between listed and unlisted bonds in Appendix 2. We test for differences between listed and unlisted bonds using the matched sample later in the paper.

We also provide summary statistics for the top bonds in the sample. A bond is designated as the firm's top bond if the bond has the most institutional trading out of all the firm's bonds on a given day. We classify a trade as institutional if it is greater than $500,000 (Ronen and Zhou, 2013). Throughout the sample period, 8,375 bonds are classified as the firm's top bond. Panel A details all top bonds in our sample. Top bonds trade, on average, at 107% of par and transact nearly $4,500,000 in average daily volume. Top bonds trade an average of nearly 7 times per day and have an average daily trade size of over $1,100,000. The average top bond trade has a bid-ask spread of $0.87.

In Panel B and C, we split the top bonds into listed and unlisted bonds. Overall, listed top bonds trade at 109% of par and transact almost $5,000,000 in daily volume. Listed top bonds trade about seven times each day, on average, and have an average trade size of over $1,200,000. The average spread for listed top bonds is $0.90. Unlisted top bonds trade above par as well, trading at 104% of par. Unlisted top bonds appear to conduct slightly less average daily volume than listed top bonds, but not by much. Unlisted top bonds have an average daily dollar volume of over $4,000,000 and an average trade size of over $1,000,000. The average spread for unlisted top bonds is $0.83.

We further explore our sample by highlighting aspects of the bond market's intraday trading activity.[3] We show the number of average bond trades during thirty minute increments from 8:00 am to 6:30 pm in Figure 1. We utilize 8:00 am – 6:30 pm because it is the overlapping time between TRACE reporting hours and the NYSE bond market's hours. The average number of bond trades increases gradually during the day, and spike around 4:00 pm, which is when NYSE core trading ends. In Figure 1, we also show the average number of trades by listed versus unlisted bonds. Listed bonds seem to trade, on average, more often than unlisted bonds trade during the trading day. Both types of bonds appear to have a trading spike around 4:00 pm, but the increase seems more drastic for unlisted bonds. It is interesting to note that unlisted bonds, which do not trade on the NYSE platform, experience a spike in trading at the close of NYSE core trading. The average number of trades drops after 4:30 pm, almost reaching zero as TRACE reporting concludes at 6:30 pm.

We continue our analysis of the bond trading day in Figure 2. Figure 2 details the average intraday bond trade size. We again focus on 8:00 am to 6:30 pm because of the overlapping hours between TRACE and the NYSE. Figure 2 shows that the average trade size is fairly consistent during the trading day, but increases leading up to 5:00 pm. The average trade size for listed and unlisted bonds begins to increase between 3:01 pm and 3:30 pm. Prior to the

[3] Reference Chan, Christie, and Schultz (1995), Chung, Van Ness, and Van Ness (1999), Lee, Mucklow, and Ready (1993), and Wood, McInish, and Ord (1985) for more information on intraday market behavior in the equities market.

increase, the average trade size for listed bonds is just under $500,000, and the average trade size for unlisted bonds is just under $300,000. After 5:00 pm, the average trade size declines. From 4:31 pm to 5:00 pm, listed bonds have an average trade size of $800,000, whereas unlisted bonds have an average trade size of $500,000 during the same period. In Figure 3, we focus on the average intraday dollar volume. Throughout the course of the day, the average dollar volume appears to stay at consistent levels before spiking between 4:01 pm to 4:30 pm for listed and unlisted bonds. Following the spike in volume, the average volume level falls to nearly zero as TRACE reporting concludes.

RESULTS

Listed bonds can trade on the NYSE or through the various bond trading platforms that report trades to TRACE. However, there is potential for execution quality and liquidity differences to exist among the trading venues. Previous research on equities documents substantial differences between trading venues. For example, Huang and Stoll (1996) find that execution costs are larger for a sample of NASDAQ stocks than for a sample of NYSE stocks; Bessembinder (1999, 2003) shows that NASDAQ stocks have higher trading costs than NYSE stocks following both tick size reductions and changes in order handling rules. We compare a sample of listed bonds that trade on both the NYSE and TRACE venues during our time period.

Appendix 3 Panel A provides statistics on the sample of listed bonds. Overall, there is a slight statistical difference in the prices of listed bond trades on the NYSE and listed bond trades on the TRACE venues. However, the difference is minimal ($0.32), which is not overly surprising; any difference in price between the trading venues indicates an arbitrage opportunity for listed bonds. On average, listed bond trades on the NYSE are less frequent, have a lower trade size, and hence, have a lower daily dollar volume than TRACE venue trades. NYSE trades are also more volatile than TRACE trades, but the difference in volatility is small (0.18) and significant only at the ten percent level. Listed bond trades on a TRACE venue have lower spreads than listed bond trades on the NYSE. NYSE trades have an average spread of $1.23, while TRACE trades have an average spread of $1.04. The difference in the spreads is significant at the one percent level. The spread differential could be driven by many factors. For one, TRACE may offer better execution quality and liquidity for bond traders. Or, the differential in spread could simply be driven by the fact that larger trades execute via TRACE, and there is an inverse relation between bond trade size and trading cost. Edwards, Harris, and Piwowar (2007), Harris and Piwowar (2006), and Goldstein, Hotchkiss, and Sirri (2007) document an inverse relation between trade size and trading cost in the bond market.

Appendix 3 Panel B provides statistics on the listed top bonds. The top bonds are the bonds with the most institutional dollar volume for each firm (Ronen and Zhou, 2013). There is no difference in the price of top bond trades on the NYSE and TRACE venues. Top bonds trade more times each day, have higher daily dollar volume, and have larger average trade sizes on the TRACE venues than top bond trades on the NYSE. TRACE trades in top bonds have lower spreads than NYSE trades in top bonds. NYSE top bond trades have an average bid-ask spread of $1.13, while TRACE top bond trades have an average spread of $0.92. The $0.21 difference is significant at the one percent level.

An important aspect of market quality is the bid-ask spread. In this section, we focus on the spread. We note in the last section that listed bond trades appear to have lower spreads and that TRACE spreads are lower for listed bonds than NYSE spreads. Model 1 utilizes the full sample of bond trades, whereas Model 2 (Model 3) utilizes listed (unlisted) bond trades. We estimate the following spread regression model:

$$\begin{aligned}\text{Bid Ask Spread} = {} & \beta_0 + \beta_1 \text{Dollar Volume} + \beta_2 \text{Number of Trades} + \beta_3 \text{Trade Size} + \\ & \beta_4 \text{Volatility} + \beta_5 \text{Top Bond} + \beta_6 \text{Years to Maturity} + \beta_7 \text{Firm Size} + \beta_8 \text{Investment Grade} \\ & + \beta_9 \text{TRACE Execution} + \beta_{10} \text{Listed} + \varepsilon\end{aligned}$$

Appendix 4 provides bid-ask spread regression results. Our main variable of interest in the bid-ask spread regressions is the *Listed* variable. The *Listed* variable is equal to one if a bond is listed. We find a negative relation between bond listing and the bid-ask spread. The magnitude of the coefficient indicates that listed bond spreads are \$0.14 lower than unlisted bond spreads. The negative relation between bond listing and spread provides evidence that bond listing provides some value, in the form of reduced trading costs, to bond traders.

In addition to bond listing variable, we are also interested in the *Top Bond* variable in Models 1, 2, and 3. Focusing on the *Top Bond* variable allows us to see the relation between institutional trading activity and the bond bid-ask spread, given that top bonds are the bonds with the most institutional trading volume. We follow Ronen and Zhou (2013) in designating the top bond as the bond with the most institutional trading dollar volume for each firm, with institutional trading measured as trades exceeding \$500,000. The *Top Bond* variable is equal to one if the bond has the most institutional trading for each firm's bonds on a given day.

The *Top Bond* coefficient is negative in all three regression models. For the full sample of bonds, top bonds spreads are \$0.42 lower than the spreads of other bonds. For listed bonds (Model 2), top bonds have spreads that are \$0.33 lower than other bonds, and unlisted top bonds (Model 3) have spreads that are \$0.59 lower than other bonds. Although we do not test for differences in the coefficients here, it appears that being the firm's top bond has more value for unlisted bonds, given the magnitude of the coefficient. The control variables in the regressions conform to general expectations. Similar to Edwards, Harris, and Piwowar (2007), the regression models show that bonds with more time to maturity have larger spreads. The larger spread for bonds with longer maturities is likely driven by potential interest rate risk. Additionally, we find that investment grade bonds have lower bid-ask spreads. Edwards, Harris, and Piwowar (2007) also document a negative relation between bond spread and credit quality.

We estimate the bid-ask spread regressions for the top bonds in our sample to shed further light on the relation between institutional trading and spread since top bonds, by design, are the bonds with the most institutional trading. While we document a negative relation between bond listing and the bid-ask spread in the full sample of bonds, we find the opposite in the top bond sample. Listed top bond trades have spreads that are $0.08 larger than unlisted top bond trades. Otherwise, the control variables in the top bond regressions yield coefficients similar to the full sample bid-ask spread regressions. We find that volatility and time to maturity have a positive relation with the bid-ask spread, while investment grade has a negative relation with the spread.

We are also interested in the intraday pattern of the bond bid-ask spread. The U-shaped intraday spread pattern in equities is well documented (see McInish and Wood, 1992), but less is known about the intraday pattern of bond spreads. In Figure 4, we show the average bond spread throughout the trading day. Like previous figures, we utilize 8:00 am to 6:30 pm because it is the overlapping time between the NYSE trading hours and TRACE reporting hours. The Figure shows that spreads steadily increase during the morning trading hours, before leveling off between 10:01 am to 10:30 am. Spreads appear to increase between 3:31 pm to 4:00 pm before peaking in the following half hour. The spike in spreads seems the most drastic for unlisted bonds. However, following the increase, spreads fall sharply leading up to the end of TRACE reporting at 6:30 pm.

Previous research documents an inverse relation between bond trade size and bond spread (Edwards, Harris, and Piwowar, 2007). We see if this relation holds for both listed and unlisted bonds in Appendix 5. In Panel A, we detail the average spread by trade size for the full sample of bonds, for listed bonds, and for unlisted bonds. Our findings are similar to previous work by Goldstein, Hotchkiss, and Sirri (2007).[4] We find a consistent negative relation between trade

[4] Other research documents the inverse relation between bond trade size and bid-ask spread, including Edwards, Harris, and Piwowar (2007) and Harris and Piwowar (2006).

size and bond spread for the full sample of bonds, for listed bonds, and for unlisted bonds. While we test for differences between listed and unlisted bonds using the matched sample later in the paper, it appears in Appendix 5 that listed bonds have lower spreads than unlisted bonds, on average, for the full sample, small sized trades, and medium trades.

In Panel B, Quartile 1 includes the most active bonds in our sample, and Quartile 4 includes the least active bonds in our sample. Panel B shows that bond spread and trading activity have an inverse relation. The most active bonds appear to have lower spreads ($0.99) than the least active bonds ($1.56). The same relation holds for listed and unlisted bonds. The most active listed bonds have an average spread of $0.95, and the least active listed bonds have an average spread of $1.80. The range of spread from the most active to the least active is not as drastic for unlisted bonds, however. The most active listed bonds have an average spread of $1.07, and the least active unlisted bonds have an average spread of $1.51.

We also examine whether listing influences the price efficiency of bonds. O'Hara and Ye (2011) utilize volatility as a measure of price efficiency in equities, and Bennet and Wei (2006) show that volatility decreases for stocks that change their listing venue from NASDAQ to the NYSE. We measure volatility following Downing and Zhang (2004) using the following equation:

$$\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$$

We use the following regression model to estimate volatility:

$$\begin{aligned}\text{Volatility} = {} & \beta_0 + \beta_1\text{Dollar Volume} + \beta_2\text{Number of Trades} + \beta_3\text{Trade Size} + \beta_4\text{Top Bond} \\ & + \beta_5\text{Years to Maturity} + \beta_6\text{Firm Size} + \beta_7\text{Investment Grade} + \beta_8\text{TRACE Execution} \\ & + \beta_9\text{Listed} + \varepsilon\end{aligned}$$

We present our bond volatility regression results in Appendix 6. Our main variable of interest is the *Listed* variable. The *Listed* variable is equal to one if a bond is listed. We find that listed bonds are more volatile than unlisted bonds and document a positive relation between bond listing and volatility in Model 1. The *Listed* coefficient is significant at the one percent level. The positive relation between bond listing and volatility conflicts with our expectations, given the predictions that exchange listing positively influences price efficiency. There are two possible explanations for the positive relation between bond listing and volatility. One explanation is trading activity. We document earlier that listed bonds trade more than unlisted bonds, and more trading activity leads to higher volatility. The second explanation is simply the structure of the bond market. The bond market is fragmented, and we know that fragmentation positively influences volatility (O'Hara and Ye, 2011).

The top bond variable is equal to one if a bond has the most institutional trading for each firm on a given trading day; following Ronen and Zhou (2013), a trade is classified as institutional if it is greater than $500,000. The *Top Bond* indicator variable is also of interest because it helps detail the relation between bond volatility and institutional trading activity since the top bond is the bond with the most institutional trading activity. We find (weak) evidence that top bonds are more volatile than non-top bonds. We document a weak positive relation between top bond status and volatility for the full sample of bonds and the sample of unlisted bonds. However, we find no relation between top bond status and volatility for the sample of listed bonds. The control variables in the volatility regressions conform to expectations. We find that bonds with more time to maturity have higher levels of volatility than bonds with less time to maturity, and bonds with investment grade ratings have lower levels of volatility that non-investment grade bonds.

Next, we study volatility for top bonds to further understand the relation between institutional trading and volatility. In Model 4, we find evidence that listed top bonds are more volatile than unlisted top bonds. The positive relation between bond listing and volatility for top bonds is somewhat puzzling, given that we find no relation between top bond status and volatility for listed bonds in Model 2. In Figure 5, we further detail intraday bond volatility. We utilize trades that occur between 8:00 am and 6:30 pm. Generally, the figure shows that volatility increases gradually between 8:01 am and 10:00 am before leveling off to a consistent level during the majority of the trading day. Volatility spikes between 4:01 pm and 4:30 pm, and then continues to decrease during the remainder of trading.

Kadlec and McConnell (1994) find that exchange (NYSE) listing leads to an increase in the number of institutional shareholders in a firm. Specifically, they show that institutional holdings increase by 27% for listed firms following earnings announcements. We study bond trading on earnings announcement and non-announcement days. Appendix 7 presents the preliminary results comparing earnings announcement days to non-earnings announcements days[5]. Panel A includes all bonds in the sample. Panel B (Panel C) includes listed (unlisted) bonds. For the full sample of bonds, we document a slight increase in price on the earnings announcement day. We also find a corresponding increase in dollar volume and the number of trades executed on announcement days. Dollar volume increases by nearly $200,000 on the announcement day, while the number of trades increases only marginally.

In Panel B, we focus on listed bonds. We find that listed bond prices increase on announcement day, along with overall listed dollar volume. The average listed bond is priced at

[5] We replicate Appendix 7 for only top bonds, and we find results that are qualitatively similar to those presented in Appendix 7.

108.70% of par on announcement days, while the average listed bond is priced at 108.51% of par on non-announcement days. Average dollar volume increases by over $150,000 for listed bonds on announcement day, but we find no significant change in either trade size or the number of trade executions on announcement days (compared to non-announcement days). Panel C provides results for unlisted bonds, and the results are similar to those shown in Panel A. We document significant increases in bond price, dollar volume, and the number of trades for unlisted bonds on announcement days.

Kadlec and McConnell (1994) focus on the relation between exchange listing and institutional shareholders. We expand their study by focusing on institutional sized bond trading activity on earnings announcement and non-announcement days. We follow Ronen and Zhou (2013) and classify a trade as institutional if the trade size is greater than $500,000. We provide the results of our analysis[6] in Appendix 8. We focus on the price, trade size, dollar volume, number of trades, percentage dollar volume, and the percentage number of trades in Appendix 8. The percentage volume (percentage trades) is the portion of volume (trading activity) for which institutional-sized trades account. For all bonds, we find an increase in the price at which institutional-sized trades execute and a slight increase in the average institutional trade size on earnings announcements days. Institutions purchase bonds priced at 106.90% of par on announcement days, compared to 106.63% of par on non-announcement days. The average trade size increases by nearly $40,000 on announcement days.

We find that institutional dollar volume declines by over $1,000,000 on announcement days, along with the number of institutional sized trades. Perhaps the most striking results in Panel A, however, involve the percentage volume and the percentage number of trades for

[6] We replicate Appendix 8 for only top bonds, and we find results qualitatively similar to those presented in Appendix 8.

institutional sized trades. On non-announcement days, institutions account for 78.31% of dollar volume. On announcement days, this percentage falls to just 43.84%. The results are similar for the percentage of trades, only not as drastic. On non-announcement days, institution sized trades account for nearly 30% of all trades. Yet, these large trades make up only 21% of trades on announcement days. The results in Panel A could indicate one of two things. First, the results may simply mean that institutions pull back from the market (and from possible informed trading) on earnings announcements days. Or, it is possible that institutions trade prior to the announcement.

We further divide the sample into listed bonds (Panel B) and unlisted bonds (Panel C). According to listing theory and Kadlec and McConnell (1994), the level of institutional activity should increase with an earnings announcement. We find the opposite in terms of activity, however. We find lower levels of institutional dollar volume and fewer institutional sized trades on earnings announcements days. We also document a substantial drop in the percentage dollar volume and percentage number of trades for large, institution sized trades. Institutions account for 86.45% of dollar volume on non-announcement days, but only 47.64% of volume on announcement days. The same is true for the percentage of trades; institution sized trades account for 9.9% fewer trades on announcement days than they do on non-announcement days. The results for unlisted bonds are similar to those shown in Panel A.

In Appendix 8, we focus on institutional-sized trading activity. We provide results for our study of smaller, retail sized trades in Appendix 9. Panel A includes all bonds in the sample. Panel B (Panel C) includes listed (unlisted) bonds[7]. Overall, retail sized trades have lower dollar

[7] We replicate Appendix 9 for only top bonds, and we find results that are qualitatively similar to those presented in Appendix 9.

volume on announcement days than on non-announcement days. In contrast to institutional-sized trades, though, retail trades account for both a larger percentage of volume and a larger percentage of trades on announcement days than on non-announcement days. Retail trades account for just 21.69% of dollar volume on non-announcement days, but increase their portion of volume to 56.16% on announcement days. The increase in the percentage number of trades is less dramatic, but still significant. Retail trades account for 70.39% of trades on non-announcement days, increasing to 78.94% on announcement days.

We divide the sample into listed and unlisted bonds in Panels B and C. We find (generally) the same results for listed and unlisted bonds. The most striking results are, again, the differences in percentage volume and percentage number of trades on earnings and non-earnings announcement days. For listed bonds, retail trades account for only 13.55% of volume on non-earnings announcement days. However, retail trades account for over 50% of volume on announcement days. The same is true for the unlisted bonds. Retail trades make up 33.54% of volume on non-announcement days, but make up over 60% of volume on announcement days. For listed (unlisted) bonds, retail traders execute 9.9% (6.61%) more trades on announcement days than non-announcement days. Overall, we find no (strong) evidence that institutional activity increases due to a bond's listing status.

We repeat the previous analysis for a matched sample of listed and unlisted bonds. Our matching procedure closely follows Boehmer (2005)[8]. We match each listed bond to an unlisted bond using four bond specific characteristics and one firm specific characteristic. We use the following bond characteristics to match the sample: price, daily dollar volume, investment

[8] We match on a one-to-one basis like Boehmer (2005). However, our matching procedure does differ slightly from his. He matches the sample used the time period preceding his analysis, while we match our sample based on the bond average price, daily dollar volume, investment quality, years to maturity, and firm market capitalization during our 2013 time period. For an in-depth description of the propensity score matching procedure, see Boehmer (2005).

quality, and years to maturity. The firm specific characteristic is daily market capitalization. We then calculate a propensity score based on the matching characteristics, and we delete matches with propensity score differences greater than 0.01[9]. The final results of the match yield 2,086 pairs of bonds with 2,706,274 bond trades. Appendix 10 provides summary statistics on the matching properties of the sample. Panel A shows summary statistics of the matched sample. Overall, bonds in the matched sample trade at 106% of par and transact nearly $2,000,000 each day in average dollar volume. The bonds in the matched sample have, on average, eight and a half years to maturity. Panel B provides differences between the listed bond sample and the unlisted bond sample. Overall, we find no significant differences between the listed sample and the unlisted sample, and interpret the lack of difference as evidence of a well-matched sample.

To compare NYSE and TRACE trades in listed bonds, we utilize the listed bond portion of our matched sample. The results are presented in Appendix 11. Panel A provides differences for the full matched sample, and Panel B provides differences for the sample of top bonds. A bond is the firm's top bond if it has the most institutional trading (measured as the number of trades greater than $500,000) for the firm on a given trading day. For the matched sample, there is little price difference between trades on the NYSE and TRACE. We document differences in the average daily dollar volume, the average number of trades, the average trade size, the average volatility, and the average bid-ask spread, however, for trades that execute on the NYSE and trades that)execute on the TRACE reporting venues. We find that TRACE trades typically have a larger average trade size, a larger number of trades, and larger average daily dollar volume than NYSE trades. We also find that listed bond trades that execute on the NYSE have larger spreads

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[9] Boehmer (2005) refers to matching differences as "matching errors." Pairwise propensity score differences are calculated using the following equation: $\mathrm{D}_{xy} = \left|\frac{\mathrm{Price}_x}{\mathrm{Price}_\mathrm{y}}\right| + \left|\frac{\mathrm{DollVol}_x}{\mathrm{DollVol}_y}\right| + \left|\frac{\mathrm{Grade}_x}{\mathrm{Grade}_y}\right| + \left|\frac{\mathrm{Mat}_x}{\mathrm{Mat}_y}\right| + \left|\frac{\mathrm{MktCap}_x}{\mathrm{MktCap}_y}\right|$.

than listed bond trades that execute via TRACE ($1.43 compared to $1.18). Lastly, we find that NYSE trades have greater volatility than TRACE trades.

In Panel B, we focus on top bonds. Similar to the results in Panel A, we find no difference in bond price for trades that execute on the NYSE and trades that execute via TRACE. However, we document differences in the average daily dollar volume, the average number of trades, the average trade size, the average volatility, and the average bid-ask spread. Specifically, top bond trades that execute via the NYSE have lower daily dollar volume, fewer daily trades, and smaller trade size than top bond trades that execute via TRACE venues. We also find that NYSE trades in top bonds are more volatile than TRACE trades in top bonds, and that NYSE top bond trades have larger spreads ($1.36) than TRACE top bond trades ($1.07).

We replicate the bond bid-ask spread analysis for the matched sample. Appendix 12 provides spread regression results. Model 1 includes the matched sample, and Model 2 (Model 3) breaks the matched sample into listed and unlisted bonds. The p-value is for the difference in the listed and unlisted coefficients. Similar to the full sample, our main variable of interest is the *Listed* variable. The *Listed* variable is equal to one if the bond is listed. In Model 1, we document a negative relation between bond listing and the bid-ask spread (we also document a negative relation between bond listing and spread in the full sample). Consistent with the full sample of bonds, we find that top bonds have lower spreads than non-top bonds in the matched sample. The negative relation holds for the full matched sample, and for both listed and unlisted bonds. The control variables are as expected (and similar to our findings in the full sample and also to Edwards, Harris, and Piwowar, (2007)). Specifically, we find that investment grade bonds have lower spreads than non-investment grade bonds, and bonds with more time to maturity have higher spreads than bonds that are closer to maturity. Next, we focus on the bid-ask spread for top bonds in the matched sample. Model 4 provides results for the top bonds included in the matched sample, and Models 5 and 6 are for listed and unlisted bonds. Our main variable of interest is the *Listed* variable in Model 4. We find a positive relation between bond listing and the top bond bid-ask spread. Specifically, listed top bond spreads are $0.11 more than unlisted top bond spreads.

To further our study of the bond bid-ask spread, we also focus on the relation between spread and trade size. Edwards, Harris, and Piwowar (2007) find a negative relation between trade size and the bid-ask spread. To see if the inverse relation between spread and trade size holds in our sample, we break the sample into small, medium, and large sized trades in Appendix 13. Appendix 13 Panel A presents the results regarding bond trade size and the bid-ask spread. Consistent with prior literature, we document an inverse relation between trade size and bond bid-ask spread. Listed bonds have lower spreads than unlisted bonds for small and medium sized trades, while unlisted bonds have lower spreads for large trades. The difference between the listed and unlisted bond spread is significant for all trade categories.

In Panel B, we focus on the relation between trading activity and the bond bid-ask spread. Quartile 1 consists of the most active bonds over the course of the sample period, and Quartile 4 consists of the least active bonds over the course of the sample period. For listed bonds, we find that the most active bonds have the lowest bid-ask spread at $0.98 (Quartile 1) and $0.95 (Quartile 2), and the least active bonds have the largest bid-ask spread at $1.47. We find a direct relation between trading activity and bond spread for unlisted bonds, with the most active unlisted bonds having lower spreads than the least active unlisted bonds. We also compare the spreads of listed and unlisted bonds. Overall, we find a significant difference in listed and unlisted bond spreads in Quartile 2, but not for any of the other quartiles.

Lastly, we follow O'Hara and Ye (2011) and focus on bond volatility as a measure of price efficiency. Appendix 14 provides results for bond volatility regressions for the matched sample of bonds. The p-value is for the difference between listed and unlisted bond regression coefficients. Our main variable of interest is the *Listed* variable, which is equal to one if the bond is listed. We find a positive relation between bond listing and volatility, which is consistent with our findings in the full sample. We are also interested in the top bond variable. We find a significant and positive relation between top bond status and volatility for the full matched sample, and for the listed bonds in the matched sample. However, we do not find a significant relation between top bond status and volatility for the unlisted bonds. We further explore the relation between top bonds and volatility in regression Models 4, 5, and 6. In Model 4, we document a positive relation between bond listing and volatility for the top bonds included in the matched sample.

CONCLUSION

We study the impact of bond listing in the corporate bond market. Previous theoretical research by Merton (1987) documents an advantage to exchange listing in the equities market; specifically, Merton details that exchange listing in the equities market can lead to an increase in investor recognition and improved liquidity for the firm. Kadlec and McConnell (1994) show empirically that listing leads to an increase in institutional shareholders for the firm, while much research documents improved liquidity for NYSE stocks and NYSE trades (Huang and Stoll, 1996; Bennet and Wei, 2006; and Bessembinder and Kaufman, 1997).

While the above mentioned research focuses on equities, we focus on the bond market in our research. Studying the impact of exchange listing in the bond market is valuable for several reasons. First, much of the research on listing focuses on stocks, which are highly liquid assets, especially when compared to the bond market. In our sample, the average corporate bond trades just 5 times, which is substantially less than the average stock in the equity market. Bonds are also costly to trade. Documenting a market quality or trading advantage for listed (or unlisted) bonds is beneficial for traders. It is also possible that bond listing serves a signal to bond traders, similar to the firm paying dividends or beating earnings. Given the well-documented informational inefficiencies in the bond market (Kwan, 1996; Downing, Underwood, and Xing, 2009), it could be important for investors to obtain information based on bond listing.

First, we document the qualities of listed bonds. Our findings show that listed bonds tend to have lower spreads and a greater number of trades than unlisted bonds. We also find that listed bonds have greater volatility than unlisted bonds. Second, we focus on the bond bid-ask spread. We show that listed bonds have lower spreads than unlisted bonds. Listed bond spreads are $0.14 lower than unlisted bond spreads. Additionally, listed top bond spreads are $0.33 lower than the spreads of other bonds. However, we also find that NYSE bond trades in listed bonds have larger bid-ask spreads than TRACE trades in listed bonds. We find that listed top bond trades have larger spreads than unlisted top bond trades. Third, we focus on volatility and price efficiency for listed and unlisted bonds. We find that listed bonds are more volatile than unlisted bonds. Overall, there appears to be a market quality advantage to bond listing.

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APPENDICES

APPENDIX 1: TRADE LEVEL SAMPLE STATISTICS

Appendix 1: Trade Level Sample Statistics

Appendix 1 provides a trade-level description of the sample. The sample includes 6,841,030 bond trades during the year 2013. Bond trades in the sample occur from 8:00 am – 6:30 pm EST.

	% of Total Trades	% of Listed Bond Trades	% of Unlisted Bond Trades
% investment grade bond trades	73.30%	81.07%	54.32%
% high yield bond trades	26.70%	18.93%	45.68%
% trades, less than 1 year to maturity	5.19%	3.08%	10.35%
% trades, less than 5 years to maturity	44.09%	44.15%	43.94%
% trades, less than 10 years to mat.	81.53%	81.92%	80.57%
% top bond trades	52.12%	53.96%	47.62%
% trades greater than $25,000	47.36%	46.12%	50.38%
% trades greater than $50,000	34.71%	33.23%	38.30%
% trades greater than $100,000	26.23%	24.69%	29.99%
% trades greater than $500,000	13.44%	12.30%	16.22%
% trades greater than $1,000,000	6.11%	6.54%	5.08%
% trades of premium bonds	76.23%	77.90%	72.14%
% trades of discount bonds	23.13%	21.77%	26.45%
% trades at par	0.64%	0.32%	1.41%

APPENDIX 2: SAMPLE SUMMARY STATISTICS, BOND LEVEL

Appendix 2: Sample Summary Statistics, Bond Level

Appendix 2 provides summary statistics for the sample. The sample includes 6,841,030 bond trades during the year 2013. Bond trades in the sample occur from 8:00 am – 6:30 pm EST. The top bond is the bond with the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume for each bond, and the number of trades is the daily number of trades for each bond. Trade size is the average daily dollar trade size. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades.

	All Bonds				Top Bonds			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Panel A: Full Sample								
Price	12,633	$105.49	$25.16	$276.92	8,375	$107.46	$25.00	$288.81
$Vol	12,633	$1,559,216.10	$2,000.00	$82,374,604.17	8,375	$4,464,537.46	$502,000.00	$55,385,555.56
Trades	12,633	4.73	1.09	80.00	8,375	6.93	1.00	241.00
TSize	12,633	$381,336.29	$1,000.00	$5,000,000.00	8,375	$1,176,863.39	$38,148.15	$5,000,000.00
Volatility	12,633	2.15	0.00	20.21	8,375	1.99	0.00	19.77
Spread	12,633	$1.34	0.00	$9.66	8,375	$0.87	$0.00	$9.31
Panel B: Listed Bonds								
Price	5,199	$109.44	$47.83	$263.62	4,725	$109.37	$48.68	$263.62
$Vol	5,199	$2,192,225.57	$8,400.00	$82,374,604.17	4,725	$4,819,489.08	$538,000.00	$84,113,106.38
Trades	5,199	5.71	1.14	69.47	4,725	7.16	1.00	109.33
TSize	5,199	$488,023.17	$2,733.33	$4,666,666.67	4,725	$1,231,376.63	$47,727.37	$5,000,000.00
Volatility	5,199	2.17	0.01	20.21	4,725	2.08	0.04	31.32
Spread	5,199	$1.17	$0.01	$9.66	4,725	$0.90	$0.00	$7.60
Panel C: Unlisted Bonds								
Price	7,434	$102.73	$25.16	$276.92	3,650	$104.98	$25.00	$288.81
$Vol	7,434	$1,116,518.19	$2,000.00	$55,385,555.56	3,650	$4,005,045.29	$502,000.00	$55,385,555.56
Trades	7,434	4.04	1.09	80.00	3,650	6.64	1.00	241.00
TSize	7,434	$306,724.36	$1,000.00	$5,000,000.00	3,650	$1,106,294.87	$38,148.15	$5,000,000.00
Volatility	7,434	2.14	0.00	15.22	3,650	1.88	0.00	19.77
Spread	7,434	$1.45	0.00	$9.63	3,650	$0.83	$0.00	$9.31

APPENDIX 3: A COMPARISON OF NYSE AND TRACE TRADES

Appendix 3: A Comparison of NYSE and TRACE Trades

Appendix 3 compares the average summary statistics for listed bond trades that execute on the NYSE and listed bond trades that execute on TRACE. The top bond is the bond with the most institutional trading each day using a $500,000 trade size (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume for each bond on each trading venue (TRACE and the NYSE), and the number of trades is the daily number of trades for each bond on each trading venue (TRACE and the NYSE). Trade size is the average daily dollar trade size on each venue (TRACE and the NYSE). Volatility is calculated as $\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Significance is indicated at the 1%, 5%, and 10% levels by ***, **, and *.

	NYSE	Trace	Difference	T-Stat
		Panel A: All Bonds		
Price	$105.84	$105.52	$0.32*	1.87
$Vol	$10,094.86	$4,090,728.88	-$4,080,634.02***	-17.87
Trades	1.27	13.66	-12.40***	-22.21
TSize	$8,113.32	$386,042.66	-$377,929.34***	-25.50
Volatility	3.51	3.33	0.18*	1.85
Spread	$1.23	$1.04	$0.19***	4.66
		Panel B: Top Bonds		
Price	$105.08	$104.93	$0.16	0.73
$Vol	$12,028.33	$7,106,201.08	-$7,094,172.76***	-21.91
Trades	1.27	18.15	-16.88***	-20.14
TSize	$9,587.53	$611,423.91	-$601,836.38***	-25.83
Volatility	4.01	3.59	0.42***	3.05
Spread	$1.13	$0.92	$0.21***	4.24

APPENDIX 4: BOND SPREAD REGRESSIONS

Appendix 4: Bond Spread Regressions

Models 1, 2, and 3 are estimated for all bonds. Models 4, 5, and 6 are estimated for top bonds. The top bond is designated as the bond with the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. Volatility is calculated as $\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$ (Downing and Zhang, 2004). The Top Bond variable is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000. Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	All Bonds			Top Bonds		
Model	All Bonds (1)	Listed Bonds (2)	Unlisted Bonds (3)	All Top Bonds (4)	Listed Top Bonds (5)	Unlisted Top Bonds (6)
Intercept	0.8186***	0.8069***	0.7143***	0.5707***	0.7002***	0.5081***
	(13.88)	(12.83)	(14.24)	(9.68)	(10.69)	(12.98)
$Vol	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-6.32)	(-4.58)	(-8.89)	(-7.11)	(-5.38)	(-8.75)
Trades	0.0001	0.0003	0.0002	0.0010***	0.0012***	0.0009**
	(0.69)	(1.03)	(0.82)	(3.88)	(3.64)	(2.10)
TSize	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-12.43)	(-9.86)	(-10.09)	(-11.78)	(-9.58)	(-9.55)
Volatility	0.1243***	0.1063***	0.1597***	0.0814***	0.0745***	0.0948***
	(10.58)	(7.54)	(10.34)	(8.44)	(6.02)	(8.56)
Top Bond	-0.4164***	-0.3252***	-0.5878***			
	(-34.17)	(-23.31)	(-28.90)			
Maturity	0.0399***	0.0386***	0.0397***	0.0299***	0.0312***	0.0255***
	(18.97)	(15.33)	(12.11)	(14.86)	(12.51)	(8.57)
Firm Size	-0.0000***	-0.0000***	0.0000	-0.0000***	-0.0000***	-0.0000***
	(-7.92)	(-11.78)	(0.77)	(-10.77)	(-9.50)	(-5.17)
InvGrade	-0.1071***	-0.2183***	-0.0070	-0.1884***	-0.2482***	-0.0913***
	(-4.47)	(-6.83)	(-0.22)	(-7.40)	(-7.29)	(-2.74)
TRACE	0.0302	0.0463		-0.0155	-0.0142	
	(0.69)	(1.10)		(-0.35)	(-0.32)	
Listed	-0.1355***			0.0769***		
	(-7.32)			(3.91)		
R-Squared	40.62%	42.57%	41.16%	40.32%	43.38%	34.91%
F-Stat	614.94***	374.03***	394.66***	252.20***	210.13***	111.39***

APPENDIX 5: BOND SPREAD BY TRADE SIZE AND TRADING ACTIVITY

Appendix 5: Bond Spread by Trade Size and Trading Activity

Appendix 5 provides a comparison of trading costs for listed and unlisted bonds. The most active bonds in the sample are in Quartile 1, and the least active bonds in the sample are in Quartile 4. The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades.

	All Bonds	Listed Bonds	Unlisted Bonds
Panel A: Dollar Spreads by Trade Size			
All Trade Sizes	\$1.34	\$1.17	\$1.45
Less than \$100,000	\$1.42	\$1.25	\$1.54
\$100,000 - \$999,999	\$1.17	\$1.04	\$1.31
Greater than \$1,000,000	\$0.82	\$0.88	\$0.76
Panel B: Dollar Spreads by Trading Activity			
Q1 (most active)	\$0.99	\$0.95	\$1.07
Q2	\$1.29	\$1.12	\$1.45
Q3	\$1.52	\$1.44	\$1.54
Q4 (least active)	\$1.56	\$1.80	\$1.51

APPENDIX 6: BOND VOLATILITY REGRESSIONS

Appendix 6: Bond Volatility Regressions

Appendix 6 presents bond volatility regressions. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). Models 1, 2, and 3 estimate volatility for the full sample of bonds, listed bonds, and TRACE bonds. Models 4, 5, and 6 estimate volatility for all top bonds, listed top bonds, and unlisted top bonds. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. The Top Bond is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000 (Ronen and Zhou 2013). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	All Bonds			Top Bonds		
Model	Full Sample (1)	Listed Bonds (2)	Unlisted Bonds (3)	All Top Bonds (4)	Listed Top Bonds (5)	Unlisted Top Bonds (6)
Intercept	3.0355***	3.3894***	3.0082***	3.4985***	3.9290***	3.2946***
	(16.64)	(14.36)	(21.98)	(15.08)	(13.36)	(14.86)
$Vol	0.0000*	0.0000	0.0000***	0.0000**	0.0000	0.0000***
	(1.95)	(1.28)	(3.29)	(2.38)	(1.52)	(3.82)
Trades	0.0144***	0.0190***	0.0069***	0.0120***	0.0165***	0.0058**
	(6.50)	(6.69)	(2.82)	(5.82)	(6.27)	(2.36)
TSize	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-13.63)	(-9.94)	(-11.71)	(-14.20)	(-10.69)	(-12.70)
Top Bond	0.0908*	0.0616	0.1294*			
	(1.83)	(0.98)	(1.72)			
Maturity	0.1208***	0.1191***	0.1210***	0.1190***	0.1194***	0.1168***
	(25.09)	(20.51)	(10.80)	(15.75)	(15.06)	(5.35)
Firm Size	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000*	-0.0000***
	(-4.31)	(-3.24)	(-4.04)	(-3.20)	(-1.82)	(-3.24)
InvtGrade	-1.5569***	-1.6970***	-1.3399***	-1.7403***	-1.8428***	-1.5319***
	(-11.85)	(-8.58)	(-10.37)	(-9.89)	(-7.24)	(-8.06)
TRACE	-0.0423	-0.0286		-0.3296*	-0.3529*	
	(-0.27)	(-0.18)		(-1.74)	(-1.87)	
Listed	0.3402***			0.4979***		
	(3.72)			(3.41)		
RSquared	20.00%	23.00%	15.10%	18.76%	21.57%	14.31%
F-Stat	166.46***	169.44***	51.79***	129.20***	144.97***	39.50***

APPENDIX 7: EARNINGS ANNOUNCEMENTS VS. NON-EARNINGS ANNOUNCEMENT DAYS

Appendix 7: Earnings Announcement vs. Non-Earnings Announcement Days

Appendix 7 provides results a comparison of trading activity on earnings announcement days and non-earnings announcement days. Price is the average daily bond price, and trade size is the average daily trade size. Dollar volume is the average daily dollar volume, and the number of trades is the average daily number of trades. All variables are averaged at the bond level. We provide averages for the announcement day and the non-announcement day. We also provide the difference between the two days. The t-statistic is presented to denote significance. ***,**,* indicate significance at the 1%, 5%, and 10% levels.

	Ann. Day	Non-Ann. Day	Difference	T-Stat
Panel A: All Bonds				
Price	$107.31	$107.04	$0.27***	8.04
Trade Size	$418,804.73	$407,640.34	$11,164.39	1.48
Dollar Volume	$2,212,530.93	$2,020,380.72	$192,150.21***	4.21
Number of Trades	6.08	5.92	0.16**	2.53
Panel B: Listed Bonds				
Price	$108.70	$108.51	$0.19***	5.09
Trade Size	$436,105.08	$424,602.25	$11,502.83	1.14
Dollar Volume	$2,448,079.56	$2,295,620.87	$152,458.69**	2.46
Number of Trades	6.80	6.70	0.09	1.14
Panel C: Unlisted Bonds				
Price	$105.29	$104.92	$0.37***	6.24
Trade Size	$393,646.85	$382,974.62	$10,672.23	0.94
Dollar Volume	$1,870,000.05	$1,620,131.10	$249,868.95***	3.75
Number of Trades	5.04	4.79	0.25***	2.66

APPENDIX 8: EARNINGS ANNOUNCEMENT VS. NON-EARNINGS ANNOUNCEMENT DAYS, INSTITUTIONAL SIZED TRADING

Appendix 8: Earnings Announcement vs. Non-Earnings Announcement Days, Institutional Sized Trading

Appendix 8 provides results a comparison of institutional trading activity on earnings announcement days and non-earnings announcement days. Price is the average daily institutional bond price, and trade size is the average daily institutional trade size. Dollar volume is the average daily institutional dollar volume, and the number of trades is the average daily institutional number of trades. The percentage institutional dollar volume is the percentage of total volume for which institutions account. The percentage institutional number of trades is the portion of all trades for which institution sized trades account. All variables are averaged at the bond level. We provide averages for the announcement day and the non-announcement day. We also provide the difference between the two days. The t-statistic is presented to denote significance. ***,**,* indicate significance at the 1%, 5%, and 10% levels.

	Ann. Day	Non-Ann. Day	Difference	T-Stat
Panel A: All Bonds				
Institutional Price	$106.90	$106.63	$0.27***	4.94
Institutional Trade Size	$1,933,736.19	$1,895,475.25	$38,260.94*	1.92
Institutional Dollar Volume	$2,516,509.75	$3,584,444.83	-$1,067,935.08***	-19.18
Institutional Number of Trades	1.27	1.90	-0.63***	-25.69
% Institutional Dollar Volume	43.84%	78.31%	-34.47%***	-60.68
% Institutional Number of Trades	21.06%	29.61%	-8.55%***	-26.05
Panel B: Listed Bonds				
Institutional Price	$107.03	$106.84	$0.19***	3.08
Institutional Trade Size	$2,064,328.39	$2,031,984.99	$32,343.40	1.23
Institutional Dollar Volume	$2,872,678.72	$4,162,325.85	-$1,289,647.13***	-16.55
Institutional Number of Trades	1.32	2.03	-0.71***	-22.25
% Institutional Dollar Volume	47.64%	86.45%	-38.81%***	-51.76
% Institutional Number of Trades	20.74%	30.64%	-9.90%***	-23.70
Panel C: Unlisted Bonds				
Institutional Price	$106.68	$106.24	$0.44***	3.91
Institutional Trade Size	$1,696,437.68	$1,647,424.01	$49,013.67*	1.66
Institutional Dollar Volume	$1,998,574.79	$2,744,099.93	-$745,525.14***	-9.82
Institutional Number of Trades	1.20	1.71	-0.51***	-13.41
% Institutional Dollar Volume	38.31%	66.46%	-28.15%***	-33.00
% Institutional Number of Trades	21.52%	28.13%	-6.61%***	-12.52

APPENDIX 9: EARNINGS ANNOUNCEMENT VS. NON-EARNINGS ANNOUNCEMENT DAYS, RETAIL SIZED TRADING

Appendix 9: Earnings Announcement vs. Non-Earnings Announcement Days, Retail Sized Trading

Appendix 9 provides results a comparison of retail trading activity on earnings announcement days and non-earnings announcement days. Price is the average daily retail bond price, and trade size is the average daily retail trade size. Dollar volume is the average daily retail dollar volume, and the number of trades is the average daily retail number of trades. The percentage institutional dollar volume is the percentage of total volume for which institutions account. The percentage retail number of trades is the portion of all trades for which retail sized trades account. All variables are averaged at the bond level. We provide averages for the announcement day and the non-announcement day. We also provide the difference between the two days. The t-statistic is presented to denote significance. ***,**,* indicate significance at the 1%, 5%, and 10% levels.

	Ann. Day	Non-Ann. Day	Difference	T-Stat
Panel A: All Bonds				
Retail Price	$107.22	$106.97	$0.25***	7.52
Retail Trade Size	$81,253.56	$82,118.31	-$864.75	-0.87
Retail Dollar Volume	$338,559.83	$353,524.31	-$14,964.48***	-3.24
Retail Number of Trades	5.22	5.30	-0.08	-1.35
% Retail Dollar Volume	56.16%	21.69%	34.47%***	60.68
% Retail Number of Trades	78.94%	70.39%	8.55%***	26.05
Panel B: Listed Bonds				
Retail Price	$108.66	$108.49	$0.17***	4.45
Retail Trade Size	$80,019.82	$80,551.45	-$531.64	-0.43
Retail Dollar Volume	$366,479.57	$380,366.53	-$13,886.96**	-2.49
Retail Number of Trades	5.93	6.01	-0.08	-1.06
% Retail Dollar Volume	52.36%	13.55%	38.81%***	51.76
% Retail Number of Trades	79.26%	69.36%	9.90%***	23.70
Panel C: Unlisted Bonds				
Retail Price	$105.07	$104.70	$0.37***	6.17
Retail Trade Size	$83,099.13	$84,462.19	-$1,363.07	-0.81
Retail Dollar Volume	$297,959.41	$314,490.79	-$16,531.38**	-2.08
Retail Number of Trades	4.19	4.26	-0.07	-0.84
% Retail Dollar Volume	61.69%	33.54%	28.15%***	33.00
% Retail Number of Trades	78.48%	71.87%	6.61%***	12.52

APPENDIX 10: MATCHED SAMPLE SUMMARY STATISTICS

Appendix 10: Matched Sample Summary Statistics

We construct a matched sample using bond price, dollar volume, market capitalization, bond investment grade, and bond years to maturity as our matching criteria. The sample is matched at the bond level. The matched sample includes 2,706,274 trades. Summary statistics are calculated at the bond level. Price is the percentage of par. Dollar volume is the daily dollar volume for each bond. The investment grade variable is equal to one if a bond is investment grade quality. Market Capitalization is the daily stock price multiplied times daily shares outstanding. Significance is indicated at the 1%, 5%, and 10% levels with ***, **, and *.

Panel A: All Bonds

	N	Mean	Standard Deviation	Minimum	Max
Price	4,172	$106.08	$11.71	$42.85	$272.60
Dollar Volume	4,172	$1,822,735.71	$2,962,901.53	$2,416.67	$82,357,435.86
Market Cap	4,172	$53,376,174.28	$72,256,984.34	$11,523.30	$438,712,329.00
Investment Grade	4,172	0.76	0.43	0.00	1.00
Years to Maturity	4,172	8.49	7.58	0.02	29.97

Panel B: Listed Bond vs. Unlisted Bond

	N	Listed Bond Mean	Unlisted Bond Mean	Difference	T Stat
Price	2,086	$106.72	$105.44	$1.28	0.47
Dollar Volume	2,086	$1,857,091.51	$1,788,379.90	$68,711.62	0.97
Market Cap	2,086	$54,837,257.40	$51,915,091.16	$2,922,166.24	1.32
Investment Grade	2,086	0.73	0.79	-0.06	0.98
Years to Maturity	2,086	8.47	8.50	-0.03	-0.15

APPENDIX 11: MATCHED SAMPLE COMPARISON OF NYSE AND TRACE TRADES

Appendix 11: Matched Sample Comparison of NYSE and TRACE Trades

We compare listed bond trades that execute on the NYSE and listed bond trades that execute on TRACE using the matched sample. The bond with the most institutional trading each day is designated as the top bond for that firm. A trade is classified as institutional if the trade size is greater than $500,000 (Ronen and Zhou, 2013). Price is the percentage of par. Dollar volume is the daily dollar volume, and the number of trades is the average daily number of trades. Trade size is the average daily dollar trade size. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Significance is indicated at the 1%, 5%, and 10% levels by ***, **, and *.

	NYSE	TRACE	Difference	T-Stat
		Panel A: All Bonds		
Price	$102.95	$103.03	-$0.08	-0.31
Dollar Volume	$8,329.97	$3,276,823.39	-$3,268,493.42***	-9.51
Trades	1.28	11.88	-10.60***	-14.84
Trade Size	$6,772.10	$335,195.87	-$328,423.77***	-16.89
Volatility	3.89	3.59	0.30**	2.14
Spread	$1.43	$1.18	$0.25***	4.45
		Panel B: Top Bonds		
Price	$102.03	$102.22	-$0.19	-0.53
Dollar Volume	$9,400.49	$6,149,843.11	-$6,140,442.62***	-11.33
Trades	1.31	16.50	-15.20***	-12.76
Trade Size	$7,400.29	$575,750.71	-$568,350.42***	-15.90
Volatility	4.54	4.05	0.49**	2.21
Spread	$1.36	$1.07	$0.29***	3.91

APPENDIX 12: MATCHED SAMPLE BOND SPREAD REGRESSIONS

Appendix 12: Matched Sample Bond Spread Regressions

Models 1, 2, and 3 are for matched sample bonds. Models 4, 5, and 6 are estimated for matched sample top bonds. The top bond has the most daily institutional trading using a $500,000 trade size (Ronen and Zhou, 2013). The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	Matched Sample of Bonds				Matched Sample of Top Bonds			
Model	Matched (1)	Listed (2)	Unlisted (3)	P Value	Matched (4)	Listed (5)	Unlisted (6)	P Value
Intercept	0.9081***	0.9085***	0.6033***	0.2690	0.6224***	0.7745***	0.3787***	0.8397
	(9.53)	(9.91)	(10.26)		(6.32)	(7.94)	(7.05)	
$Vol	-0.0000***	-0.0000***	-0.0000***	0.3773	-0.0000***	-0.0000***	-0.0000***	0.0823
	(-4.34)	(-2.66)	(-7.43)		(-4.60)	(-2.94)	(-5.57)	
Trades	0.0000.	-0.0001	0.0013**	0.4173	0.0010**	0.0008*	0.0017*	0.2035
	(0.07)	(-0.27)	(1.97)		(2.47)	(1.87)	(1.81)	
Trade Size	-0.0000***	-0.0000***	-0.0000***	0.9637	-0.0000***	-0.0000***	-0.0000***	0.2249
	(-8.98)	(-7.41)	(-4.66)		(-8.43)	(-7.66)	(-4.34)	
Volatility	0.1084***	0.0931***	0.1956***	0.3819	0.0722***	0.0645***	0.1224***	0.2901
	(5.76)	(4.98)	(14.12)		(4.60)	(4.03)	(12.76)	
Top Bond	-0.3889***	-0.3179***	-0.5946***	0.1960				
	(-21.00)	(-15.29)	(-19.13)					
Maturity	0.0401***	0.0404***	0.0334***	0.2911	0.0306***	0.0329***	0.0218***	0.7765
	(12.04)	(10.91)	(9.10)		(9.97)	(9.42)	(4.95)	
Firm Size	-0.0000***	-0.0000***	0.0000	0.2235	-0.0000***	-0.0000***	-0.0000***	0.3893
	(-5.60)	(-7.14)	(0.90)		(-6.70)	(-6.88)	(-4.75)	
InvTGrade	-0.1967***	-0.2460***	-0.0190	0.3159	-0.2064***	-0.2470***	-0.0452	0.3175
	(-5.43)	(-5.84)	(-0.40)		(-5.52)	(-5.56)	(-0.95)	
TRACE	0.0043	0.0160			-0.0258	-0.0178		
	(0.06)	(0.24)			(-0.35)	(-0.24)		
Listed	-0.0626**				0.1146***			
	(-2.21)				(3.95)			
R-Squared	41.47%	43.90%	43.81%		42.01%	44.48%	36.01%	
F Statistic	258.00***	190.29***	159.39***		145.99***	154.00***	44.14***	

APPENDIX 13: MATCHED SAMPLE BOND SPREAD BY TRADE SIZE AND TRADING ACTIVITY

Appendix 13: Matched Sample Bond Spread by Trade Size and Trading Activity

The most active bonds in the sample are in Quartile 1, and the least active bonds in the sample are in Quartile 4. The bid-ask spread is calculated as the difference between the weekly average seller reported trades and the weekly average buyer reported trades. The difference column represents the difference between listed bond spread and unlisted bond spread. Significance is determined using t-stats. Significance is indicated at the 1%, 5%, and 10% levels using ***, **, and *.

	All Bonds	Listed Bonds	Unlisted Bonds	Difference	T Stat
Panel A: Dollar Spreads by Trade Size					
All Trade Sizes	$1.24	$1.12	$1.36	-$0.25***	-7.83
Less than $100,000	$1.33	$1.17	$1.49	-$0.32***	-9.52
$100,000 - $999,999	$1.10	$1.02	$1.22	-$0.20***	-5.76
Greater than $1,000,000	$0.81	$0.90	$0.74	$0.16***	5.11
Panel B: Dollar Spreads by Trading Activity					
Q1 (most active)	$1.01	$0.98	$0.95	$0.03	0.28
Q2	$1.10	$0.95	$1.36	-$0.42***	-3.60
Q3	$1.33	$1.20	$1.40	-$0.20	-1.41
Q4 (least active)	$1.51	$1.43	$1.56	-$0.13	-0.59

APPENDIX 14: MATCHED SAMPLE BOND VOLATILITY REGRESSIONS

Appendix 14: Matched Sample Bond Volatility Regressions

Volatility is calculated as $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$ (Downing and Zhang, 2004). Models 1, 2, and 3 estimate volatility for the full sample of matched bonds, listed bonds, and TRACE bonds. Models 4, 5, and 6 estimate volatility for all top bonds, listed top bonds, and unlisted top bonds. Dollar volume is the daily bond dollar volume, and the number of trades is the daily number of trades per bond. Trade size is the dollar amount of each trade. The Top Bond is equal to one for the bond with the most institutional trading each day. A trade is categorized as institutional if it is greater than $500,000 (Ronen and Zhou, 2013). Years to maturity is the number of years to maturity as of the trade date. Firm size is the daily stock price multiplied times daily shares outstanding. Investment Grade is equal to one for an investment grade bond, as designated in the TRACE master file. TRACE Execution is equal to one if a trade occurs on a TRACE reporting venue. Listed is equal to one if the bond is listed. T stats are in parentheses, and significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *. Standard errors are clustered at the bond level.

	Matched Sample of Bonds				Matched Sample of Top Bonds			
Model	Matched (1)	Listed (2)	Unlisted (3)	P Value	Matched (4)	Listed (5)	Unlisted (6)	P Value
Intercept	3.1464***	3.4480***	3.1068***	0.3113	3.7922***	4.2791***	3.3987***	0.8435
	(10.22)	(9.92)	(19.91)		(9.77)	(9.29)	(18.38)	
$Vol	0.0000	0.0000	0.0000***	0.3713	0.0000	0.0000	0.0000***	0.4306
	(0.32)	(0.59)	(3.03)		(0.72)	(0.68)	(3.82)	
Trades	0.0185***	0.0224***	0.0029	0.4004	0.0164***	0.0212***	0.0013	0.9683
	(4.14)	(4.13)	(1.52)		(3.79)	(3.86)	(0.98)	
Trade	-0.0000***	-0.0000***	-0.0000***	0.4159	-0.0000***	-0.0000***	-0.0000***	0.2431
Size	(-8.03)	(-6.86)	(-10.65)		(-8.55)	(-7.56)	(-10.64)	
	0.1985***	0.2266**	0.0116	0.4434				
Top Bond	(2.79)	(2.46)	(0.16)					
	0.1135***	0.1155***	0.0962***	0.5058	0.1084***	0.1153***	0.0770***	0.9025
Maturity	(12.42)	(9.22)	(12.18)		(7.71)	(5.88)	(6.59)	
	-0.0000***	-0.0000***	-0.0000	0.5981	-0.0000***	-0.0000**	-0.0000**	0.6967
Firm Size	(-4.47)	(-4.18)	(-1.27)		(-2.88)	(-2.39)	(-2.03)	
	-1.5523***	-1.6686***	-1.1977***	0.3161	-1.6649***	-1.8042***	-1.3171***	0.3175
InvtGrade	(-9.16)	(-7.65)	(-6.98)		(-7.36)	(-5.88)	(-6.54)	
	-0.1431	-0.0959			-0.6069*	-0.6062*		
TRACE	(-0.52)	(-0.34)			(-1.75)	(-1.78)		
	0.3870***				0.6126***			
Listed	(3.78)				(4.06)			
RSquared	20.54%	22.30%	14.22%		18.65%	20.11%	14.01%	
F Statistic	82.13***	62.09***	61.10***		67.18***	49.99***	47.35***	

FIGURES

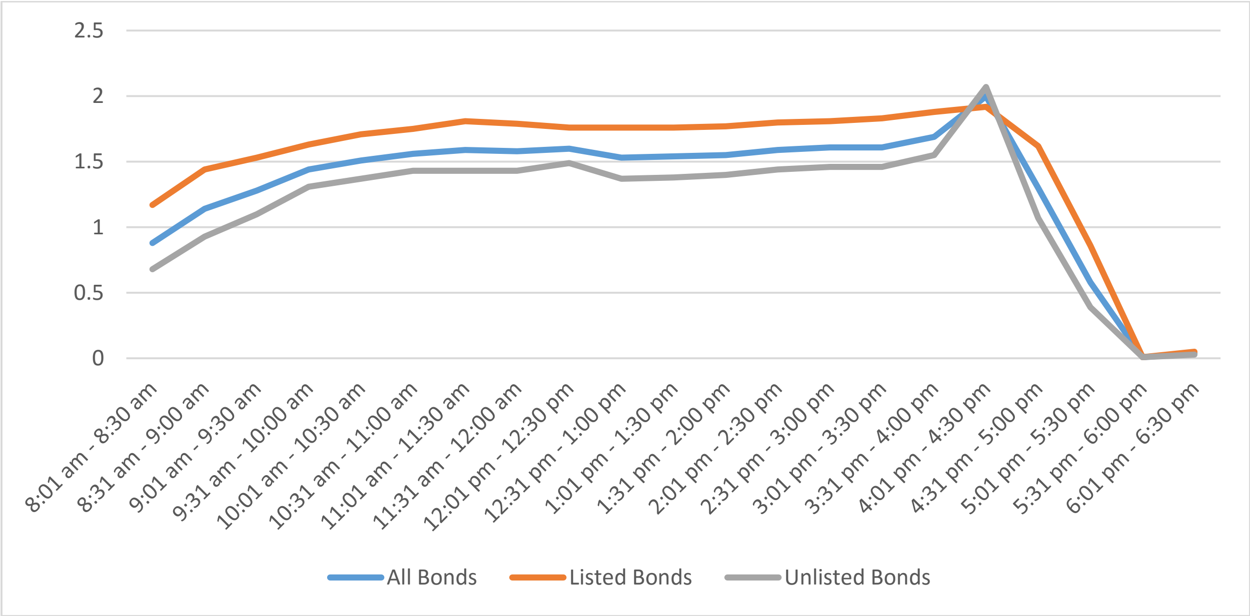

Figure 1. Intraday Average Number of Bond Trades.

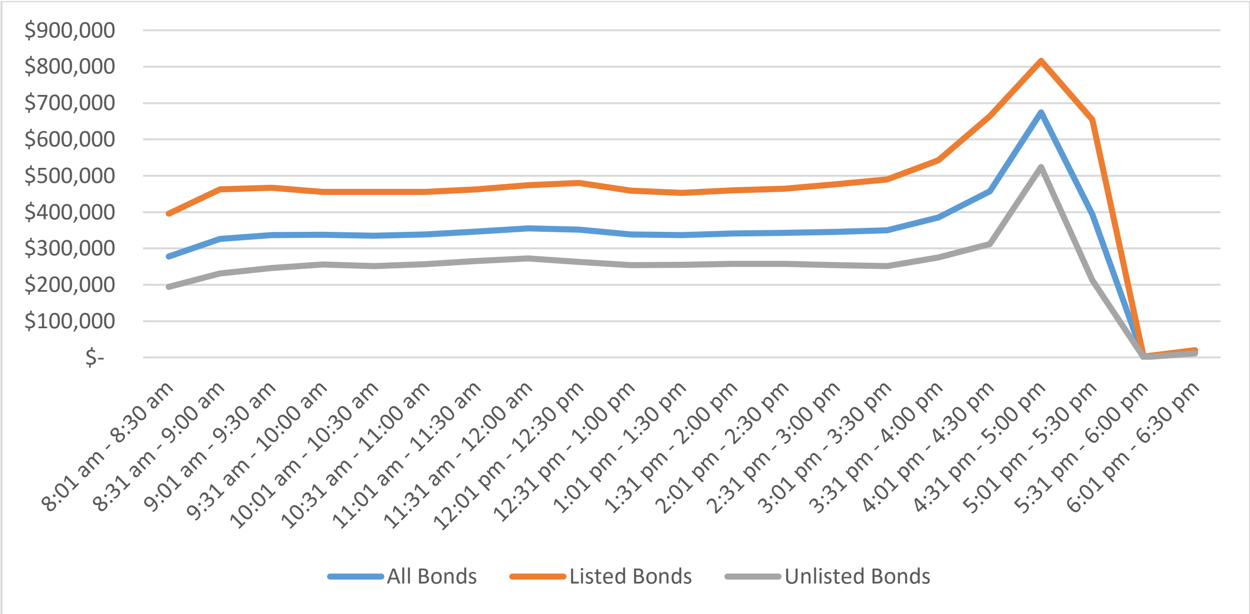

Figure 2. Average Intraday Bond Trade Size.

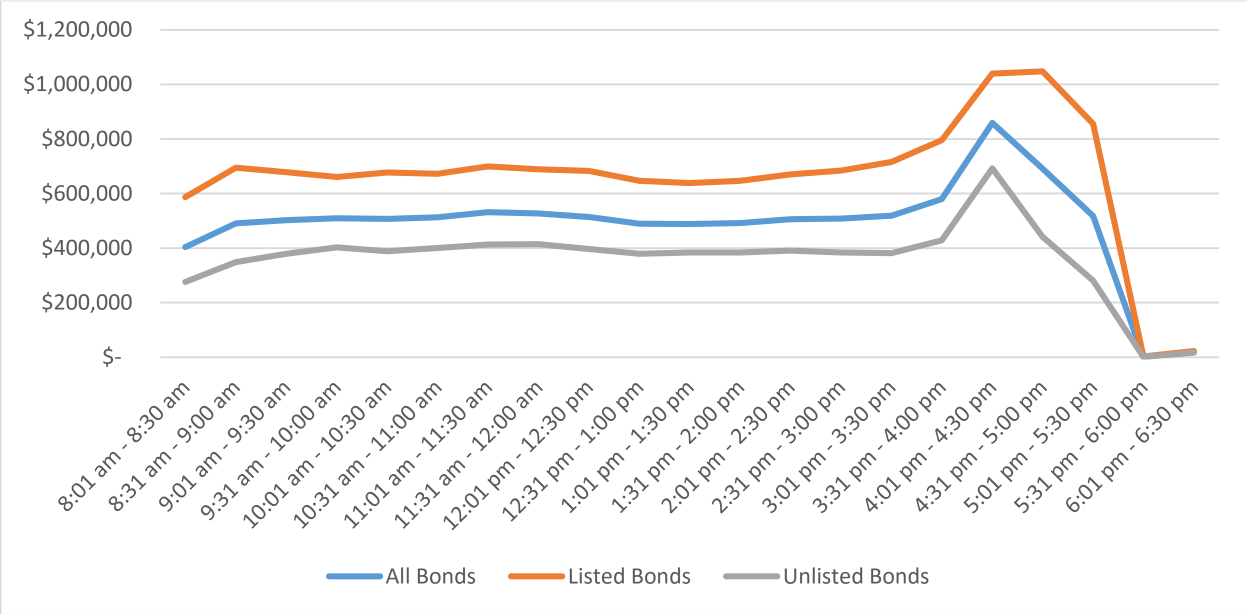

Figure 3. Average Intraday Bond Dollar Volume.

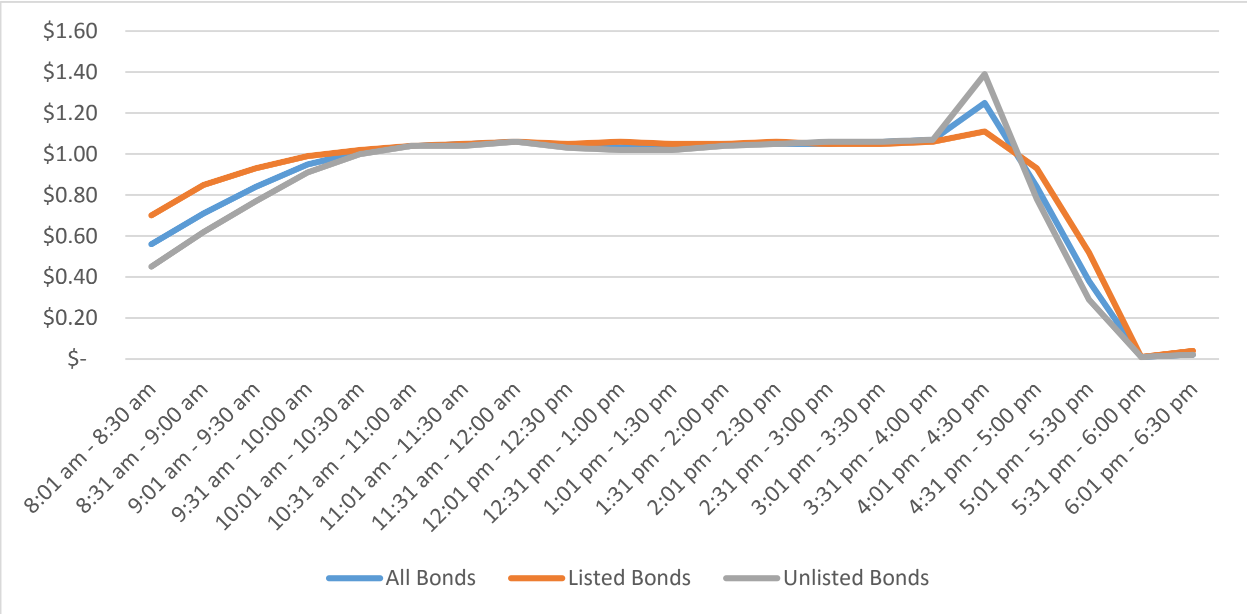

Figure 4. Average Intraday Bond Bid-Ask Spread.

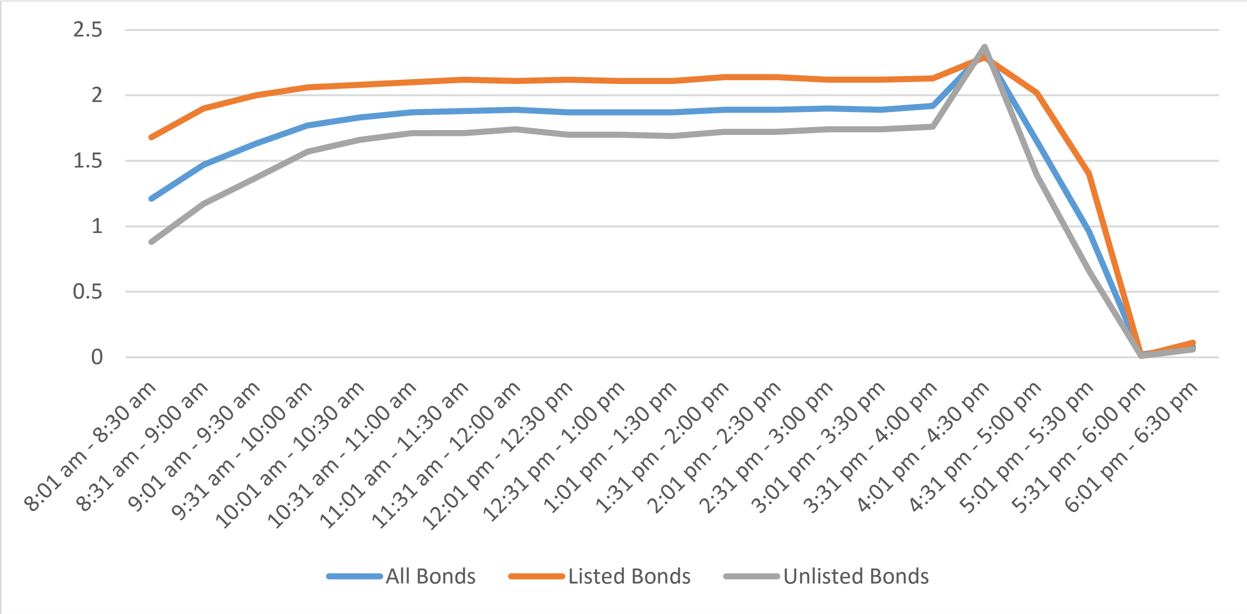

Figure 5. Average Intraday Bond Volatility.

PART 2: MUNICIPAL BOND TRADING, INFORMATION RELATEDNESS, AND NATURAL DISASTERS

INTRODUCTION

Natural disasters and the costs associated with the ensuing damage can be extensive. The damages linked to Hurricane Sandy exceed \$20 billion, and Hurricane Katrina damages are estimated to be at least \$125 billion. In 2011, a tornado devastated Joplin, Missouri, directly causing \$3 billion in damages (Hamilton, 2012). Natural disasters carry information in the form of damages for geographic areas and the firms tied to these areas (Loughran and Schultz, 2004). Generally, the information is not known until the amount of damage is realized.

Some corporations are able to shift production or operations to areas of the country not damaged by a disaster, but the viability of municipalities, and hence municipal bonds, is directly tied to the damaged area. For example, the cash flows of revenue bonds are funded from the income earned by the bond projects (toll road, stadium, etc). If a structure is damaged in a storm or natural disaster, then the bond funding that project potentially loses its payoff source. Additionally, tax revenues may be affected if citizens leave an area after a natural disaster. Trading of municipal bonds can be affected by natural disasters as well; local investors may be too distracted preparing for and recovering from the storm to balance their bond portfolios in the days leading up to and following a natural disaster. Using firms headquartered in areas struck by blizzards, Loughran and Schultz (2004) show that equity trading volume declines on both the day of the blizzard and the subsequent trading day. The authors contribute the decline in trading volume to the storm serving as a source of distraction for traders.

Studying the municipal bond market and its reaction to natural disasters allows us to examine the bond market's ability to absorb information. Prior bond market research implies that both the municipal and corporate bond markets are inherently slow incorporating information into bond prices. Kwan (1996) shows that stocks react to information faster than corporate bonds, and Downing, Underwood, and Xing (2009) document that non-investment grade corporate bonds lag equities in their ability to incorporate information. Green, Li, and Schurhoff (2010) show that municipal bonds are quick to include information that pushes prices up, but are slow to include information that pulls prices down.   Given that natural disasters likely carry negative information, we believe that local traders may be distracted by the natural disaster, and hence, alter trading activity leading up to and following the event (Loughran and Schultz, 2004), leading to slower incorporation of the association information in municipal bond prices.

RELATED LITERATURE

Loughran and Schultz (2004) study local trading of NASDAQ stocks. The authors focus on the effect cloud cover and blizzards have on trading. The authors examine trading around forty-eight blizzards from 1984 to 1997. While they find little relation between cloud cover and stock returns, Loughran and Schultz document a reduction in trading volume for the firms headquartered in cities struck by a blizzard. The reduction in trading volume is substantial; volume falls by 17% on the day the storm hits and by 15% on the subsequent day. Loughran and Schultz blame the decline in trading volume on local investor distraction and claim that local traders may be too busy preparing for and recovering from the blizzard to participate in trading.

Shive (2012) conducts a study that indirectly examines trading activity and natural disasters. Shive focuses on power outages and the market quality of firms headquartered in areas affected by the outage. Of the 114 blackouts that occur in her sample from 2002 to 2010, all but two are caused by events such as ice storms and hurricanes. Shive states that the blackout constrains local trading activity and finds that the blackout influences several aspects of trading. First, both total volatility and idiosyncratic volatility decline during the power outage. Second, quoted spreads fall by 2.5% during the blackout, which the author credits to a reduction in adverse selection. Third, both volume and turnover decline during the blackout. The author conjectures the changes in trading are due to local traders' inability to participate in the market during the blackout.

While previously mentioned research focuses on equity markets, there is potential for natural disasters to affect other security types. We focus on the municipal bond market and natural disasters. Municipal bonds are unique in that their claims and payoffs are often tied directly to funded projects, such as toll roads, bridges, and stadiums, which may be damaged by a natural disaster. Unlike firms that have the ability to shift operations or production schedules to other locations, municipalities do not possess this flexibility. Damage to or loss of a funded structure can severely affect the municipality's ability to meet its debt obligations. Additionally, the potential loss of population (and subsequent tax revenues) can detrimentally influence a municipality's viability. As such, the damages that result from the natural disaster provide information as to the well-being of the municipality and its surrounding areas.

HYPOTHESES

We study the efficiency of the municipal bond market and establish if contagion exists following natural disasters. The commonality literature suggests market wide shocks may link individual security liquidity and market liquidity. Cabelle and Krishman (1994) propose the following variables as measures of information relatedness: trading volume, number of trades, volatility, spreads, and returns. Chordia, Roll, and Subrahmanyam (2000) document commonality in liquidity and spreads, and Hasbrouck and Seppi (2001) show commonality exists in stock trading volume. In this study, we utilize the previously mentioned variables to determine if contagion exists among municipal bonds. Studying the municipal bond market's reaction to natural disasters allows us to examine the bond market's ability to absorb information and also to describe the behavior of bond traders following a disaster.

First, we focus on spreads. Spreads in the municipal bond market may increase following a natural disaster as a way for dealers to compensate for additional risk. In the days following a natural disaster, the amount of damage (the information) caused by the storm is revealed and this information is disseminated into the municipal bond market. It is also possible that spreads will fall following the natural disaster; Loughran and Schultz (2004) and Shive (2012) detail that local traders are often constrained following a natural disaster. If local traders are unable to access municipal bond markets after the natural disaster occurs, then a reduction in asymmetric information may occur as local, perhaps more informed, traders are distracted. Shive (2012) documents a reduction in spread following electricity blackouts. She theorizes the reduction in spreads result from local trader's inability to access the market, which in turn results in less information asymmetry in the market following the blackout.

Common factors, such as economic fundamentals or liquidity demands, are also shown to influence the trading environment (Hasbrouck and Seppi, 2001). Areas adjacent to the municipality where the natural disaster occurs may also be impacted following the storm. It is possible that adjacent areas are economically linked to the damaged area or that investors in surrounding areas are distracted (perhaps by news reports or relief efforts), leading to surrounding investors participating less in their own local municipal bond market following the disaster. Jiang, McInish, and Upson (2009) measure information relatedness using firm SIC codes and study the trading activity of stocks that continue trading during a trading halt. Even though the halt is unrelated to the other firms in the industry (identified by SIC code), they find that spreads increase during the halt for related firms. Using the above literature, we form the following hypotheses:

H1A: There is a relation between municipal bond spreads and local natural disasters.

H1B: There is a relation between informationally-related municipal bond spreads and natural disasters.

Second, we examine volume and number of trades. Loughran and Schultz (2004) study local trading of NASDAQ stocks, focusing on cities struck by a blizzard. They find a substantial 17% reduction in trading volume on the day the storm strikes the city, and they document a 15% reduction in trading volume on the trading day after the blizzard. Loughran and Schultz claim that local investors may be too busy preparing for and recovering from the blizzard to participate in trading, thus influencing the reduction in trading volume. Shive (2012) also documents a reduction in trading volume following electricity blackouts and finds that stock turnover falls following an electricity blackout. Loughran and Schultz study trading volume of stocks headquartered in cities unaffected by a blizzard and find no effect on trading volume. Yet, Jiang, McInish, and Upson (2009) find that the number of trades increases for informationally-linked firms during a trading halt. Using the above literature, we present the following hypotheses:

H2A: Volume decreases for municipal bonds in the days following a local natural disaster.

H2B: Volume decreases for informationally-linked municipal bonds following a natural disaster.

H3A: The number of trades decreases for municipal bonds in the days following a local natural disaster.

H3B: The number of trades decreases for informationally-linked municipal bonds following a natural disaster.

Third, we focus on bond market efficiency. The municipal bond market is generally inefficient and opaque due to its operating as a decentralized dealer market. A natural disaster provides information to a geographic area, often in the form of damages. There is a lag between the natural disaster occurring and the amount/level of damages becoming known. During this time of information gathering and dissemination, the municipal bond market is filled with uncertainty. The uncertainty may result in increased bond market volatility. Jiang, McInish, and Upson (2009) propose volatility as a measure of information relatedness. In contrast, local investors may be distracted or constrained both during and following the disaster. Shive (2012) uses volatility as a measure of price discovery and shows that total volatility and idiosyncratic volatility fall during an electricity blackout. The reduction in total volatility is stronger for small cities, high income areas, and during pre-earnings/merger announcement periods. The reduction in idiosyncratic volatility is more pronounced for small firms with no analyst following. If local investors play an information-based role in municipal bond markets (as both Shive, 2012, and Loughran and Schultz, 2004, show they play in equities), then it is possible that volatility will fall during and following a local natural disaster. The natural disaster may also distract investors in neighboring locations, thus influencing their participation in their own municipal bond markets. Using the above information, we propose the following hypotheses:

H4A: There is a relation between municipal bond volatility and local natural disasters.

H4B: There is a relation between informationally related municipal bond volatility and natural disasters.

Another test of market efficiency is to determine if abnormal returns are earned following a natural disaster. If markets are efficient, the occurrence of a natural disaster that does not interrupt the operations of a funded project should not influence bond returns. However, prior literature shows that natural disasters can influence stock returns. Cabelle and Krishman (1994) identify returns as a measure of firm relatedness. Lamb (1998) focuses on hurricanes and their impact on stock price. In Lamb's study, firms with hurricane risk exposure experience negative excess returns around a hurricane. Firms without hurricane exposure are unaffected by both Hurricane Andrew and Hurricane Hugo. Shelor, Anderson, and Cross (1990) focus on an October 17, 1989 California earthquake. Specifically, they investigate the impact that the property damage from the earthquake has on California real estate firms. Their results show negative excess returns for real estate firms on the day of the earthquake, but do not show any evidence of significant negative returns for other California-based firms not involved in real estate. Jiang, McInish, and Upson (2009) use industry to classify related firms. Based on the above mentioned literature, we present the following hypotheses:

H5A: Municipal bonds have negative abnormal returns following a local natural disaster.

H5B: Informationally related municipal bonds have negative abnormal returns following a natural disaster.

SAMPLE AND DATA

We use municipal bond transaction data for January 2010 through December 2013 from the Municipal Securities Rulemaking Board (MSRB). The MSRB municipal bond database includes all trades by registered broker-dealers. Each trade is identified as a dealer purchase from a customer, dealer sale to a customer, or interdealer trade, and each trade record includes the CUSIP, security information, coupon, yield, par value traded, and price. The data initially includes 35,834,399 bond transactions. We require bonds in the sample to trade nine times each year (Edwards, Harris, and Piwowar, 2007)[1], which reduces our sample to 33,250,257 trades. We also require bonds in the sample to trade at prices above 25% of par in order to remove municipalities close to bankruptcy or default, and we remove transactions with data entry errors/missing values. These two deletions further reduce our sample to 32,571,012 trades. After constructing both the weekly volatility measures and the weekly spread measures, our final data sample includes 20,553,922 trades in 331,429 municipal bonds issued by the municipalities in all fifty states in the United States. We obtain each bond's issuing state and whether a bond is general obligation or revenue from the MSRB's Electronic Municipal Market Access (EMMA) website. Appendix A provides information on the number of bonds outstanding by state during our time period.

[1] Harris and Piwowar (2006) study transactions costs in the municipal bond market and require bonds in their sample to trade at least six times. We follow Edwards et al (2007) and use a slightly more restrictive requirement (nine times each year) to control for potential nonsynchronous trading, given the illiquidity of the municipal bond market and the four year length of our trade sample. We replicate each appendix using the Harris and Piwowar restriction, and the results are qualitatively similar.

We also utilize natural disaster data from the National Climactic Data Center. We include three types of natural disasters in the sample: tornados (1,173 events), wildfires (1,877 events), and hurricanes/tropical storms (46 events). The National Climactic Data Center provides information regarding the disaster start date/time, end date/time, and states affected. We match municipal bonds affected by natural disasters based on the bond's issuer. Appendix B includes information on the number of natural disasters in our sample.

THE MUNICIPAL BOND MARKET DESCRIPTION

Municipal bonds are issued by city, county, and state governments, and also by entities such as electric companies, schools, and hospitals. Municipal bonds are unique in that they are excluded from the Securities Exchange Act of 1934 and are not subject to oversight by the U.S. Securities and Exchange Commission. The MSRB governs the municipal bond market. The municipal bond market is a highly fragmented market, and the bonds trade in a decentralized over-the-counter market. Municipal bonds are typically issued in deals, where several different securities are issued at the same time. The various bonds in the deal, all designed to fund the same project, have different maturities, coupons, yields, and offer prices.

The municipal bond market is historically fragmented and opaque (Harris and Piwowar, 2007, and Green, Li, and Schurhoff, 2010). One way that the MSRB seeks to improve transparency in the municipal bond market is through the implementation of its website, EMMA, and real time trade reporting. EMMA provides information about the municipal bond market, municipal bond disclosure statements, and post-trade transparency information for municipal bonds. Municipal bond trades are reported to the MSRB's real-time transaction reporting system (RTRS) within 15 minutes of the trade execution, and the trades then are posted publicly to the EMMA website. Real time trade reporting includes real-time prices for most trades occurring after January 31, 2005.

Appendix 1 provides a description of the trade executions in our sample. Panel A includes information on all bond trades in the sample. 7.82% of bond trades involve a taxable municipal bond. The majority of bond trading appears to take place in bonds with at least 10 years to maturity. Additionally, small trades make up a large portion of the trade sample. Trades of less than \$25,000 account for over 50% of the transactions from 2010 to 2013, while trades greater than \$100,000 account for just 16% of transactions.

The majority of bonds in the sample trade above par. Dealer sales to customers make up a large portion of trades at 44.46% of transactions, while dealer purchases (interdealer trades) make up 25.09% (30.45%). California, Texas, New York, Pennsylvania, and Illinois bonds account for nearly 50% of all transactions in the sample (henceforth referred to collectively as the top five bond issuing states). Generally, the trading activity in dealer purchases, dealer sales, and interdealer trades is similar to that shown for the full sample. Additionally, the trading activity in the top five bond issuing states is similar to the full sample (Panel B).

Appendix 2 provides bond level summary statistics for all bonds in the sample and also for the top five bond issuing states. Panel A includes the full sample of trades, and Panels B, C, and D are for interdealer trades, dealer purchases, and dealer sales. The average bond in our sample trades roughly 2.94 times per day with an average trade size of over \$275,000 and an average price of 103.25% of par. The average daily dollar volume for municipal bonds is nearly \$730,000. On average, municipal bonds have a 1.5% spread. There appears to be slight differences between the full sample of bonds and the top five issuing states' bonds, but we do not test for statistical differences in Appendix 2. The average price for a "top five" bond is 101.90% of par. The average number of trades, the average daily volume, and the average trade size for top five bond issuing states are all similar to those for the full sample. Bonds issued by the top five bond issuing states in the sample have an average trade size of \$300,000 and transact over \$770,000 in average daily volume. Additionally, the average spread for a top five bond is 1.62%.

In Panel B, we provide summary statistics for interdealer trades, both for the full sample and for the top five bond issuing states. Interdealer trades have an average price of 103.18% of par, and are nearly $160,000 in dollar size on average. Interdealer trades make up roughly $320,000 of daily dollar volume. Dealer purchases (Panel C) have an average price of 102.43% of par and an average trade size of about $342,000. On average, interdealer purchases occur 1.11 times per bond per day, and the average daily dealer purchase volume is almost $400,000. Dealer sales (Panel D) have an average price of 103.93%. The average dealer sale size is roughly $266,000, and dealer sales account for nearly $377,000 in average daily volume. Interestingly, dealer sales have a positive return (on average), whereas interdealer trades and dealer purchases have negative average returns.

RESULTS

First, we focus on municipal bond trading activity on the natural disaster event day compared to non-event days. An event day is any trading day on which a natural disaster occurs, and non-event days are all trading days on which no natural disaster occurs. We detail our first analysis of municipal bond trading and natural disasters in Appendix 3. Panel A includes tornados, Panel B includes wildfires, and Panel C includes hurricanes/tropical storms. Overall, we find significant differences between event days and non-event days. For tornados, we find that the dollar volume is roughly $40,000 higher on the event days compared to all other trading days, which is in contrast to the previous literature showing a reduction in volume on disaster event days (Loughran and Schultz, 2004, and Shive, 2012). The number of trades is marginally higher on tornado event days. Tornado event days' trade sizes are nearly $6,000 larger than non-event days' trade sizes. Both spreads and volatility are lower on event days than on non-event days, which is consistent with Shive's findings of lower volatility and lower spreads during electricity blackout periods. Specifically, spreads are 0.02% lower on tornado event days, and volatility is 0.05% lower. Lastly, we show that bond returns are lower on tornado event days than on non-event days.

Panel B provides the event days and non-event days comparison for wildfires. We show that daily volume is roughly $57,000 higher, and that the average trade size is nearly $11,000 larger on the event days than on the non-event days. This finding of increasing activity in the event period is, again, the opposite of what Shive (2012) shows for equities. Similar to Panel A, we document marginal differences in the number trades between the two time periods, and we also show that both spreads and volatility are lower on the event days (similar to tornado events in Panel A and also consistent with previous findings). We detail hurricane/tropical storm event days compared to non-event days in Panel C. Unlike the findings in Panels A and B, we find no significant difference in daily volume on hurricane event and non-event days. However, we find that both spreads and volatility are lower on the hurricane event days, which is a consistent finding across all three disaster types analyzed in the paper.

We document significant differences between event days and non-event days for municipal bonds and natural disasters in Appendix 3. We attempt to isolate where these differences might be coming from by separating the trade sample into small (less than $25,000), medium ($25,001 – $100,000), and large (greater than $100,001) trades. These statistics are located in Appendix 4. Panel A details the event days, and Panel B details the non-event days in Appendix 4. We focus on the percentage volume, percentage trades, and bid-ask spreads in Appendix 4. Examining what trade size changes, if any, occur during natural disasters can also shed some insight on who is trading in the municipal bond market. Trade size is used to measure retail versus institutional trading in the bond market; typically, trades exceeding either $100,000 (Edwards, Harris, and Piwowar, 2007) or $500,000 (Ronen and Zhou, 2013) are considered institutional. We designate trades as "large" or institutional if the trade size exceeds $100,001 in our paper.[2]

In Appendix 4, Panel A, we focus on the natural disaster event days, which are defined as the day a natural disaster occurs. We find that small trades account for the largest portion of both dollar volume and the number of trades on both the event days and the non-event days (regardless of disaster types). Consistent with previous literature, we document an inverse

[2] We replicate any results involving trade size designations using $500,000 to designate large trades. We utilize $100,000 in our main tests because only a small percentage of trades exceed $500,000.

relation between trading costs and trade size in the bond market.[3] Large trades account for the smallest portion of both volume and number of trades in both time periods for all disaster types.

The first three columns provide information for tornados. Medium trades account for a slightly smaller portion of volume on tornado event days (compared to non-event days), while large trades account for a slightly greater portion of volume on event days than non-event days. We do not document any significant differences in spreads between the two time periods for medium and large trades (for tornados). We find that small trades have a 0.02% lower spread on tornado event days than on non-event days. For wildfires, we find that small trades have significantly lower spreads on wildfire event days than on the non-event days. The magnitude of the difference in spreads, however, is only 0.01% for wildfire events.

The last columns in Appendix 4 provide results for hurricanes/tropical storms. We document significant differences in bond spreads for small and medium trades on hurricane event days and non-event days. We find that small and medium trades have lower spreads on hurricane event days compared to non-event days. Small trade spreads are 0.05% lower in the event period, and medium trade spreads are 0.03% lower in the event period. We do not show any significant differences in large trade spreads between hurricane/tropical storm event days and non-event days.

Despite finding some significant differences in trade sizes between event days and non-event days, the differences between the two time periods do not appear to come from one single trade size group. We make a second attempt to isolate the origin of the differences on natural disaster event days by separating interdealer trades, dealer purchases, and dealer sales. We present the relevant statistics results in Appendix 5. The left-side columns provide results for

[3] See Goldstein, Hotchkiss, and Sirri, 2007; Edwards, Harris, and Piwowar, 2007; and Harris and Piwowar, 2006.

tornado event days and non-event days. We find a significant difference in spreads for both interdealer trades and dealer purchases. Both interdealer trades and dealer sales account for a smaller portion of volume (trades) on tornado event days than on non-event days, but dealer purchases account for a larger proportion of both volume and trades on tornado event days compared to non-event days.

The results for both wildfire and hurricane events are similar to, if not more pronounced, than the results for tornado events. Both interdealer trades and dealer sales account for a smaller portion of volume and trades on event days than non-event days for wildfires and hurricanes, while dealer purchases account for a larger portion of volume and trades during event periods. Dealer purchases increase by 0.77% (0.70%) for dollar volume (number of trades) on wildfire event days compared to non-event days. For hurricane events, dealer purchases increase by 1.55% (1.59%) for dollar volume (number of trades) on event days compared to non-event days for hurricanes. With the exception of interdealer trades during hurricanes/tropical storms, the differences in spreads between event and non-event days are small in magnitude for both wildfires and hurricanes.

In previous appendices, we focus on comparing event days and non-event days. We now further our analysis by studying the pre-event week, the event day(s), and the post-event week. The pre-event week is the five trading days prior to the natural disaster, and the post-event week is the five trading days following the natural disaster. The event days are the actual day(s) of the natural disaster. Appendix 6 presents the comparison for the tornado pre, during, and post event periods. We also test for the following differences between the three time periods: the pre-event week and the event day(s); the event day(s) and the post event week; and the pre-event week and the post-event week. Dollar volume is slightly higher in the tornado pre-event week than the post event week – roughly $727,000 compared to $708,000. We find marginal (but significant) differences in the average number of trades in all three time periods; trades generally fall during both the tornado event days and the post-event weeks, as compared to the pre-event weeks.

Panel B provides results for wildfires. We find no significant difference in volume in the pre-event weeks and event days, but we find that volume decreases following the natural disaster. The volume decline following a wildfire is similar to Loughran and Schultz (2004), who document a reduction in trading volume on the trading day following a blizzard. Volume is roughly $688,000 during the wildfire event days, and around $672,000 in the week following the wildfire. We find marginal differences in both the number of trades and spreads in the three time periods, and we show that volatility is highest during the event period for wildfires. In contrast, Shive (2012) finds that volatility declines during electricity blackouts. Additionally, we find that returns fall significantly from the pre-event week to the post-event week for wildfires. The results for hurricanes (Panel C) are somewhat weaker than those shown in Panels A and B. Returns fall drastically from the pre-event week to the post-event week, falling from 0.02% to -0.03%. The drop in returns is consistent with Lamb's (1998) finding that firms with hurricane risk exposure experience negative returns following a hurricane.

Previous financial literature documents the existence of commonality, or relatedness, among securities. Specifically, the literature points out that both market and industry wide liquidity influence the liquidity of individual securities (Chordia et al, 2000). Commonality (or relatedness) has potential implications for trading activity and liquidity, particularly when we consider the impact of natural disasters. Chordia et al. point out that certain market-wide shocks have the potential to influence wide-spread liquidity, and as such, influence if metrics such as spreads, volatility, and volume (as well as other liquidity measures) change in similar ways.

Natural disasters, and the subsequent damages they cause, can interrupt trading in the municipal bond market. Given that the physical and monetary damage of a natural disaster is not immediately known, the potential liquidity shock following the disaster may have long-term effects in the municipal bond market. The question remains of whether or not natural disasters influence the activity of related municipal bonds as well.

In this section, we further our analysis of municipal bond trading around natural disasters by focusing on potential commonality between the bonds. We follow Chordia, Roll, and Subrahmanyam (2000) in designating informationally related securities, municipal bonds in our case, as similar securities (all other bonds) issued by the same state. Appendix 7 provides the results from our first examination into commonality among municipal bonds for tornados. Panel A includes spread estimations. Overall, we find significant differences in spreads for bonds affected by a tornado and for the related bonds. Spreads are, on average, about 0.18% higher for the related bonds during the tornado pre-event weeks, event days, and post-event weeks. Spreads are 1.66% in all three time periods for the bonds affected by tornados, and roughly 1.84% for the related bonds in all three time periods. We conduct an F test to determine differences in distributions across spreads, and we find no differences for the distributions of bonds affected by tornados. However, we find significant differences in the distribution for the group of informationally related bonds.

Panel B provides statistics for average daily dollar volume. Average dollar volume is significantly higher in the informationally related bonds across all time periods for tornados. Daily volume is about $734,000 for the bonds affected by tornados, while volume is roughly $840,000 for the informationally related bonds – a difference of about $100,000. In the tornado pre and post event periods, volume is around $130,000 higher for the related bonds compared to the bonds affected by the disaster. As in Panel A, we test for differences in daily volume distribution and document a difference only for the informationally related bonds.

Similar to Panels A and B, we find lower daily trading activity for bonds affected by tornados compared to the informationally related bonds in Panel C. However, the difference in the number of trades per day is marginal during all three time periods, hovering around 0.15 trade. We document significant differences in the number of trades distribution for related bonds and those bonds influenced by tornados. The results in Panel D for volatility somewhat contrast those shown in the previous three panels. We find that volatility is higher during all three time periods (by roughly 0.08%) for tornados. Consistent with Panels A and B, we find no difference in distribution for bonds affected by tornados. However, we document a significant difference in volatility distribution for the informationally related bonds. Lastly, we find that returns are significantly lower for the bonds influenced by tornados compared to the informationally related bonds. The returns are substantially lower in the tornado post-event week, with a negative difference of 0.21%. We find significant differences in distribution in returns for both the bonds affected by tornados and the related bonds.

We continue our focus on municipal bonds and relatedness in Appendix 8. Appendix 8 provides our analysis for wildfires. Spreads and volume are lower for the bonds affected by the wildfires (compared to the informationally related bonds) in the pre-event week, event week, and post-event weeks. Significantly more trading occurs in the related-bonds compared to the bonds influenced by the wildfires. Volatility is higher (by roughly 0.07%) for the bonds directly related to the wildfires. Lastly, we find significant differences in returns in the wildfire pre-event weeks and event weeks between the two groups of bonds. The informationally related bonds outperform the bonds affected by the wildfires by 0.53% in the pre-event weeks, and continue to outperform them on the event days (by 0.10%). We find no significant difference in returns during the post-event weeks.

Appendix 9 provides our analysis of the bonds affected by hurricanes/tropical storms. In contrast to the previous two appendices (Appendices 7 and 8), spreads are higher for the bonds affected by hurricanes during both hurricane pre-event weeks and event days. Spreads are 0.04% higher in the hurricane pre-event weeks and 0.06% higher during the actual hurricane. We find no significant difference in spreads for the hurricane post-event weeks. Also in contrast to the previous results, dollar volume is higher for the bonds affected by hurricanes/tropical storms than for the related bonds. Specifically, bond volume is nearly $400,000 higher during hurricane pre-event and post-event weeks, and volume is roughly $340,000 higher on event days. Volatility (Panel D) is significantly greater for bonds affected by hurricanes/tropical storms, with volatility being between 0.65% – 0.67% higher for affected bonds. We also find significant differences in returns between the two groups of bonds. Returns for both groups of bonds are positive in the hurricane pre-event weeks, but the returns for the bonds affected by natural disasters fall to 0.00% on the event days. Returns continue to fall in the post-event week, reaching -0.03%.

We further our analysis of municipal bonds, relatedness, and natural disasters by estimating weekly spread regressions for 3,461,639 bond-week observations. We control for variables shown to influence spreads, including weekly dollar volume, weekly number of trades, average weekly trade size, weekly volatility, and the average years to maturity (Edwards, Harris, and Piwowar, 2007). We also control for the bond being a revenue bond, taxable, and issued by one of the top five bond issuing states (in terms of the number of bonds). Lastly, we control for state-specific variables. We use annual population from the U.S. Census Bureau to control for state size, and we control for potential state wealth effects by controlling for the median annual income and the annual general fund revenue for each state (Ang, Green, and Xing, 2015).

The event period dummy variable is equal to one during the days of the natural disaster, and zero otherwise. The post-event period dummy variable is equal to one the five trading days following the natural disaster, and zero otherwise. Both the event period and post-event period dummies allow us to compare spreads to the pre-event period (the five trading days prior to the natural disaster), as we hold out the pre-event variable for comparison. We also control for potential commonality or relatedness among securities with a related security variable. The related security variable is the average weekly spread of bonds issued by the same state. The interaction terms between event (post-event) period and related security variable are of particular interest because the two variable allow us to determine if natural disasters influence both municipal bonds and related municipal bonds.

We present the spread regression estimations in Appendix 10. We divide the regressions based on events. Model 1 is for tornados, and Models 2 and 3 are for wildfires and hurricanes/tropical storms. Spreads fall significantly on the event days for both tornados and wildfires. Specifically, spreads are 0.03% lower during the tornado event days and 0.05% lower during the wildfire event days. We find no significant relation between spreads and the event days for hurricanes/tropical storms. Spreads are lower in the post-event days compared to the pre-event weeks for tornados and hurricanes. Post-event spreads are 0.04% lower than pre-event levels for tornados, and 0.11% lower in the post-event weeks for hurricanes.

In addition to the event and post-event weeks, we are also interested in the relation between spreads and informationally-related bonds. We find a positive relation for related bonds in both the event period and the post-event weeks for tornados. Related security spreads increase by 0.02% during the event days, and by 0.03% during the post-event weeks. For wildfires, we find a significant relation for related security spreads during the event days only. Related security spreads increase by 0.02% during the event days for wildfires. We find no relation for informationally-related bonds during the event days for hurricanes, but we document a significant positive relation during the post-event weeks. Specifically, related bond spreads increase by $0.08 during the hurricane post-event weeks compared to the pre-event weeks.

We find that volatility positively influences spreads. We also find that bonds with longer times to maturity have larger spreads. The positive relation between time to maturity and spreads is likely due to increased interest rate exposure/risk over the life of the bond. Additionally, we find that both revenue bonds and taxable bonds have significantly higher spreads than general obligation bonds and non-taxable bonds. Lastly, bonds issued by the top five bond issuing states appear to have slightly lower spreads than bonds issued by other states.

We also control for the size and potential wealth of states. While we do not find economically significant relations in terms of population, income, and fund revenue, we can draw a few generalities from the coefficients. States with higher incomes and higher populations appear to also have higher spreads. These states may be frequent issuers of municipal bonds (to fund projects to support the larger population), which could lead to the bonds being perceived as more risky than other bonds. General fund revenue serves as a direct measure of state income. We find a negative relation between spreads and fund revenue, indicating that bonds issued by states with higher revenues are less costly to trade.

In addition to spreads, we are also interested in potential commonality in municipal bond volatility. We provide further evidence about the market quality of municipal bonds around natural disasters in Appendix 11. Appendix 11 presents the estimated coefficients from bond volatility regressions. We estimate volatility weekly for 3,461,639 bond-week observations. Model 1 is for tornados, and Models 2 and 3 are for wildfires and hurricanes/tropical storms. We follow Downing and Zhang (2004) in estimating municipal bond market volatility with the following price range measure: $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\max} - \text{Price}_t^{\min}\right)$. We control for dollar volume, trading activity, and average trade size in the volatility regressions, and also for bond time to maturity. Additionally, we control for a bond being a revenue bond, taxable, and issued by a top five bond issuing state. Lastly, we control for state specific variables, including annual population and median income.

First, we are interested in the relation between the event period (and post event period) and volatility. We find that volatility is 0.19% lower during the event days for tornados, but we find no significant relation between volatility and the event days for either wildfires or hurricanes/tropical storms. We find a significant relation between wildfire post-event weeks and volatility, documenting a 0.10% reduction in volatility in the week following the wildfire (compared to pre-event weeks). In contrast, we find a 0.19% increase in volatility during the post-event weeks for hurricanes.

We are also interested in the relation between volatility and the informationally-related bonds in the sample. The related security variable is the average weekly volatility of municipal bonds issued by the same state. We interact the event days and post-event week dummy variables with the related security to determine what influence, if any, natural disasters have on related bond volatility. We find a 0.09% increase in volatility for related bonds during the tornado event days, but we find no significant relation for wildfires or hurricanes. We do not find a significant relation between volatility and the post-event weeks for any of the disasters in the sample – tornados, wildfires, or hurricanes. Consistent with Edwards, Harris, and Piwowar

(2007), we document a positive relation between volatility and time to maturity. The positive relation is likely a result of the increased interest rate risk in the longer maturity bonds.

Lastly, we determine the relation between municipal bond volume and natural disasters. The municipal bond market is fairly illiquid in terms of the number of trades, but there is still a large amount of dollar volume traded in the market. Some bonds trade much more frequently and more, in terms of dollar volume, than others. To explore the potential differences in volume, we focus on the most active (top quartile) and the least active (bottom quartile) bonds in terms of dollar volume in Appendix 12. We also divide the sample by events—tornados, wildfires, and hurricanes (similar to the previous appendices). We control for several bond specific factors. We control for bond time to maturity, and for whether a bond is a revenue bond, is taxable, and is issued by one of the top issuers in the sample. Lastly, we control for state specific variables, including annual state population and state median income.

The event days dummy variable is equal to one during the natural disaster, and zero otherwise. The post-event week dummy variable is equal to one the five days following the natural disaster, and zero otherwise. Both the event days and post-event week dummies allow us to compare volume to the pre-event week (the five trading days prior to the natural disaster), as we hold out the pre-event variable for comparison. We also control for potential commonality or relatedness among securities with the related security variable. The related security variable is the average weekly volume of related bonds. The interaction terms between event (post-event) weeks and related security variable are of particular interest because the two variable allow us to determine whether natural disasters influence both municipal bonds and related municipal bonds.

We find that weekly dollar volume increases during the post-event week for all three types of natural disasters. The magnitude of the increase ranges from $12 billion (hurricanes) to roughly $13.5 billion (tornados). Only bonds affected by hurricanes experience an increase in volume during the event week. For the least active bonds, the results are slightly different. We find no evidence of significant volume changes during the event days or post-event week for bonds affected by tornados. We document a significant reduction in volume during post-event weeks for bonds affected by wildfires. However, hurricane/tropical storm affected bonds have a significant increase in volume by nearly $2,000 during the post-event weeks.

Similar to previous analyses, we are interested in the potential commonality effects in municipal bond volume, and therefore, we interact the event (post-event) dummy with the related security variable. We document a significant drop in weekly bond volume for informationally-related bonds in the tornado post-event week for the most active bonds. The least active bonds appear to experience a marginal increase activity in tornado post-event weeks. The magnitude of the volume increase is roughly $1,200 for the most active bonds, while the magnitude of the volume decrease is consistently marginal, at best, for the least active bonds.

There are some additional differences between the most active and least active bonds. Regardless of activity level, time to maturity negatively influences bond volume. The negative relation is consistent with bonds being purchased and held long-term by investors. Whether a bond is a revenue bond or not appears to reduce volume in the thinly traded bonds (by roughly $600). However, being a revenue bond increases volume in the most active bonds. Taxable bonds have lower volume than non-taxable bonds across all regression models, regardless of bond activity level. Intuitively, the lower volume for taxable bonds make sense, especially given the number of securities to choose from in the municipal bond market. Investors will likely choose to capitalize on the tax benefits municipal bonds offer and choose to trade the non-taxable securities over the taxable securities.

Unexpectedly, bonds issued by the top five bond issuing states in the sample have significantly lower volume than the bonds issued by municipalities in the other 45 states. The negative relation is likely due to the fact that we are comparing the volume for bonds issued by only five states to the volume of bonds issued by the other 45 states combined. In terms of state characteristics, we show that bonds from more populated states and states with higher incomes trade more dollar volume. The positive relation between population (income) and dollar volume is consistent regardless of bond activity level.

CONCLUSION

Natural disasters can cause extensive damage to municipalities. Previous research by both Loughran and Schultz (2004) and Shive (2012) shows that natural disasters influence trading activity and market quality. We seek to study what effects, if any, natural disasters have on municipal bond trading. Studying the municipal bond market is valuable. Municipalities are constrained in that they cannot shift productions or operations following natural disasters, whereas some corporations have the ability to do so when facilities are damaged. Additionally, municipal bond viability is directly tied to the area(s) damaged by a natural disaster.

We use a sample of municipal bond trades from 2010 to 2013, and we find that natural disasters influence municipal bond trading. Spreads are lower on not only tornado event days but also wildfire event days. Additionally, spreads remain lower during the five trading days following the event compared to pre-event spreads. We do not find evidence that spreads change on hurricane event days; however, spreads fall during the five trading days following the hurricane. For tornados, wildfires, and hurricanes, dollar volume increases the five trading days after the natural disaster.

We further our analysis of the municipal bond market by studying both the bonds affected by natural disasters and related bonds. Specifically, we find that spreads are higher for related bonds than for the bonds affected by both tornados and hurricanes. Both dollar volume and number of trades are higher for the related bonds compared to the bonds affected by both tornados and wildfires. The finds are different for hurricanes, though. Spreads for bonds affected by hurricanes are higher during the event than spreads for the related bonds. Dollar volume is also higher for bonds affected by hurricanes than for related bonds during the hurricane event. Overall, our results document links between the municipal bond market and natural disasters and provide evidence about the overall market quality and efficiency of the municipal bond market following natural disasters.

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APPENDICES

APPENDIX 1: MUNICIPAL BOND TRANSACTION CHARACTERISTICS

Appendix 1: Municipal Bond Transaction Characteristics

Appendix 1 provides transaction summary characteristics of all municipal bonds that trade more than nine times from 2010 – 2013. The sample includes 331,429 individual securities issued by the 50 states and 20,553,922 trades. Panel A provides information for the full sample of bonds, and Panel B provides information for the top five bond issuing states in the sample (California, Texas, New York, Pennsylvania, and Illinois). The second column represents all trades. The third column represents interdealer trades. The fourth column represents dealer purchases, and the fifth column represents dealer sales.

	All Transactions	Interdealer Trades	Dealer Purchases	Dealer Sales
Panel A: All Bond Trades				
% trades in taxable bonds	7.82%	6.93%	7.05%	8.86%
% trades, bonds less than 1 year to maturity	2.65%	2.14%	3.55%	2.50%
% trades, bonds with 1 – 5 years to maturity	10.96%	11.56%	13.01%	9.39%
% trades, bonds with 5 – 10 years to maturity	16.41%	17.80%	18.24%	14.42%
% trades, bonds with 10 – 20 years maturity	34.60%	35.49%	34.14%	34.26%
% trades, bonds with 20+ years maturity	35.38%	33.01%	31.07%	39.43%
% trades less than $10,000	23.88%	19.31%	21.80%	28.19%
% trades $10,001 – $25,000	29.37%	29.62%	26.15%	31.02%
% trades $25,001 – $50,000	19.27%	20.74%	18.93%	18.45%
% trades $50,001 – $100,000	11.76%	13.32%	12.94%	10.02%
% trades $100,001 – $250,000	7.21%	8.73%	8.35%	5.53%
% trades greater than $250,000	8.51%	8.27%	11.84%	6.79%
% trades of premium bonds	64.89%	64.26%	62.01%	66.94%
% trades of discount bonds	29.28%	34.32%	31.64%	24.49%
% trades at par	5.84%	1.41%	6.35%	8.57%
% trades in Top 5 Issuers	46.41%	47.69%	45.85%	45.84%
% Interdealer Trades	30.45%			
% Dealer Sales	44.46%			
% Dealer Purchases	25.09%			
Panel B: Trades in Top Five Bond Issuing States				
% trades in taxable bonds	9.42%	8.67%	8.20%	10.63%
% trades, bonds less than 1 year to maturity	2.82%	2.29%	3.58%	2.78%
% trades, bonds with 1 – 5 years to maturity	10.93%	11.54%	12.87%	9.39%
% trades, bonds with 5 – 10 years to maturity	16.16%	17.33%	17.88%	14.36%
% trades, bonds 10 – 20 years to maturity	33.78%	34.47%	33.56%	33.41%
% trades in bonds with 20+ years maturity	36.31%	34.37%	32.12%	40.06%
% trades less than $10,000	21.45%	17.88%	19.47%	25.12%
% trades $10,001 – $25,000	28.89%	28.80%	25.44%	30.91%
% trades $25,001 – $50,000	19.74%	20.82%	19.24%	19.25%

% trades $50,001 – $100,000	12.66%	14.00%	13.85%	11.03%
% trades $100,001 – $250,000	7.85%	9.24%	9.04%	6.18%
% trades greater than $250,001	9.41%	9.25%	12.96%	7.52%
% trades of premium bonds	64.22%	63.81%	61.11%	66.26%
% trades of discount bonds	30.12%	34.67%	32.14%	25.74%
% trades at par	5.66%	1.52%	6.75%	8.00%
% Interdealer Trades	31.30%			
% Dealer Sales	43.91%			
% Dealer Purchases	24.79%			

APPENDIX 2: SAMPLE SUMMARY STATISTICS, BOND LEVEL

Appendix 2: Sample Summary Statistics, Bond Level

Appendix 2 provides summary characteristics of all municipal bonds that trade more than nine times from 2010 – 2013. The sample includes 331,429 individual securities issued by the 50 states and 20,553,922 trades. Panel A provides information for the full sample of bond trades for all bonds and for bonds issued by the top five municipal bond issuing states in the sample (California, Texas, New York, Pennsylvania, and Illinois). Panel B includes interdealer trades, Panel C includes dealer purchases, and Panel D includes dealer sales (for all municipal bond trades and also for bonds issued by the top five issuers). Price is the average daily price for each bond. Dollar volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. The return is the trade-to-trade return.

	All Municipal Bonds				Top Five Municipal Bond Issuing States			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Panel A: Full Sample								
Price	331,159	103.25%	25.00%	155.29%	142,254	101.90%	25.00%	155.29%
$Vol	331,159	$729,893.75	$1,979.47	$993,255,000.00	142,254	$771,291.97	$2,000.00	$541,162,162.00
Trades	331,159	2.94	1.00	157.00	142,254	2.94	1.00	132.07
TSize	331,159	$277,288.89	$484.10	$153,333,333.00	142,254	$297,126.43	$1,000.00	$153,333,333.00
Volatility	331,159	1.84%	0.00%	102.83%	142,254	1.94%	0.00%	51.82%
Spread	331,159	1.58%	0.00%	18.05%	142,254	1.62%	0.00%	18.05%
Return	331,159	0.08%	-22.72%	1,308.64%	142,254	0.09%	-15.45%	124.12%
Panel B: Interdealer Trades								
Price	293,932	103.18%	25.00%	156.74%	126,971	101.82%	25.00%	156.74%
$Vol	293,932	$319,723.25	$440.75	$991,085,000.00	126,971	$339,547.83	$1,000.00	$110,146,667.00
Trades	293,932	1.94	1.00	98.00	126,971	1.97	1.00	46.00
TSize	293,932	$159,494.25	$300.25	$99,000,000.00	126,971	$167,814.31	$484.71	$98,100,000.00
Volatility	293,932	2.06%	0.00	165.58%	126,971	2.14%	0.00%	51.82%
Spread	293,932	1.71%	0.00%	18.05%	126,971	1.75%	0.00%	18.05%
Return	293,932	-0.12%	-62.38%	495.09%	126,971	-0.09%	-54.02%	495.09%
Panel C: Dealer Purchases								
Price	324,616	102.43%	25.00%	156.19%	139,511	101.10%	25.00%	156.19%
$Vol	324,616	$393,357.79	$212.00	$717,256,216.00	139,511	$429,278.16	$212.00	$717,256,216.00
Trades	324,616	1.11	1.00	45.00	139,511	1.11	1.00	45.00
TSize	324,616	$342,465.67	$212.00	$358,634,775.00	139,511	$371,894.89	$212.00	$358,634,775.00
Volatility	324,616	1.79%	0.00%	102.83%	139,511	1.88%	0.00	51.82%
Spread	324,616	1.52%	0.00%	18.05%	139,511	1.57%	0.00%	18.05%
Return	324,616	-0.86%	-49.34%	5,137.10%	139,511	-0.88%	-29.26%	156.36%
Panel D: Dealer Sales								
Price	331,145	103.93%	25.00%	155.45%	142,250	102.60%	25.00%	155.45%
$Vol	331,145	$376,947.15	$705.80	$576,400,000.00	142,250	$399,125.07	$1,000.00	$200,990,000.00
Trades	331,145	1.62	1.00	155.00	142,250	1.62	1.00	98.84

TSize	331,145	$266,598.26	$705.80	$140,000,000.00	142,250	$286,300.91	$1,000.00	$140,000,000.00
Volatility	331,145	1.81%	0.00%	102.83%	142,250	1.90%	0.00%	51.82%
Spread	331,145	1.53%	0.00%	18.05%	142,250	1.58%	0.00%	18.05%
Return	331,145	0.96%	-14.37%	175.47%	142,250	1.00%	-9.40%	25.91%

APPENDIX 3: EVENT DAY DIFFERENCES

Appendix 3: Event Day Differences

Appendix 3 provides a comparison between event period and non-event periods in the sample (2010 – 2013). The event period is the week of the event, and the non-event period is all other trading days. Panel A includes tornados, Panel B includes wildfires, and Panel C includes hurricanes/tropical storms. Price is the average daily price for each bond. Dollar volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. The return is the trade-to-trade return. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Event Days	Non-Event Days	Difference
Panel A: Tornadoes			
Price	103.20%	103.20%	0.00
Dollar Volume	$705,058.14	663,925.86	$41,132.28***
Number of Trades	2.78	2.74	0.04***
Trade Size	$285,057.95	$279,196.21	$5,861.74**
Volatility	1.88%	1.94%	-0.05%***
Bid-Ask Spread	1.61%	1.63%	-0.02%***
Return	0.05%	0.07%	-0.02%***
Panel B: Wildfires			
Price	102.80%	102.61%	0.20%***
Dollar Volume	$685,520.42	$626,466.59	$57,053.83***
Number of Trades	2.75	2.70	0.06***
Trade Size	$273,875.25	$262,897.19	$10,978.06***
Volatility	1.95%	1.99%	-0.04%***
Bid-Ask Spread	1.65%	1.66%	-0.01%***
Return	0.11%	0.09%	0.02%***
Panel C: Hurricanes/Tropical Storms			
Price	104.45%	103.60%	0.83%***
Dollar Volume	$768,732.45	$757,811.55	$10,920.91
Number of Trades	2.78	2.79	-0.01
Trade Size	$333,257.95	$329,400.94	$3,857.01
Volatility	1.99%	2.18%	-0.19%***
Bid-Ask Spread	1.69%	1.76%	-0.07%***
Return	0.14%	0.04%	0.10%*

APPENDIX 4: EVENT DAYS AND NON-EVENT DAYS TRADE SIZE DIFFERENCES

Appendix 4: Event Days and Non-Event Days Trade Size Differences

Appendix 4 provides event period and non-event period statistics, as well as differences between the two time periods, for small trades, medium trades, and large trades. Small trades are less than $25,000 in size. Medium trades are $25,001 – $100,000 in size. Large trades are greater than $100,001 in size. Summary information is calculated using 20,553,922 bond trades in 331,429 municipal bonds. Price is the average price (by trade size). Percentage volume is the portion of volume for which each trade size accounts, and percentage trades is the portion of trades for which each trade size accounts. The bid-ask spread is the weekly spread for each trade size. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Tornados			Wildfires			Hurricanes/Tropical Storms		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Panel A: Event Days									
% Vol	48.67%	33.17%	18.17%	48.05%	33.91%	18.04%	50.25%	32.68%	17.07%
% Trades	51.11%	32.52%	16.37%	50.50%	33.25%	16.25%	52.92%	31.73%	15.35%
Spread	1.91%	1.64%	1.21%	1.95%	1.67%	1.26%	2.04%	1.78%	1.22%
Panel B: Non-Event Days									
% Vol	48.48%	33.50%	18.02%	48.05%	34.02%	17.93%	50.28%	32.76%	16.97%
% Trades	50.99%	32.80%	16.21%	50.48%	33.37%	16.15%	53.21%	31.73%	15.06%
Spread	1.93%	1.64%	1.22%	1.96%	1.68%	1.26%	2.09%	1.81%	1.23%
Panel C: Differences									
% Vol	0.19%*	-0.34%***	0.15%**	0.00%	-0.11%	0.11%	-0.03%	-0.08%	0.11%
% Trades	0.13%	-0.29%***	0.16%**	0.02%	-0.11%	0.10%	-0.29%	0.00%	0.29%
Spread	-0.02%***	0.00%	0.01%	-0.01%**	-0.01%	0.00%	-0.05%***	-0.03%***	-0.01%

APPENDIX 5: EVENT DAYS AND NON-EVENT DAYS TRADE TYPE DIFFERENCES

Appendix 5: Event Days and Non-Event Days Trade Type Differences

Appendix 5 provides event period and non-event period statistics, as well as differences between the two time periods, for interdealer trades, dealer purchases, and dealer sales. Summary information is calculated using 20,553,922 bond trades in 331,429 municipal bonds. Price is the average price (by trade type). Percentage volume is the portion of volume for which each trade type accounts, and percentage trades is the portion of trades for which each trade type accounts. The bid-ask spread is the weekly spread for each trade type. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Tornados			Wildfires			Hurricanes/Tropical Storms		
	InTrades	DBuys	DSales	InTrades	DBuys	DSales	InTrades	DBuys	DSales
Panel A: Event Days									
% Vol	22.90%	36.12%	40.99%	23.34%	35.99%	40.68%	22.12%	37.49%	40.38%
% Tds	22.50%	34.94%	42.56%	22.95%	34.82%	42.23%	21.82%	36.46%	41.72%
Spread	1.83%	1.58%	1.58%	1.86%	1.63%	1.62%	1.93%	1.69%	1.69%
Panel B: Non-Event Days									
% Vol	23.43%	35.45%	41.11%	23.67%	35.22%	41.12%	22.95%	35.94%	41.10%
% Tds	23.06%	34.33%	42.61%	23.31%	34.12%	42.57%	22.64%	34.87%	42.49%
Spread	1.84%	1.57%	1.57%	1.87%	1.61%	1.62%	1.98%	1.68%	1.70%
Panel C: Differences									
% Vol	-0.53%***	0.66%***	-0.13%***	-0.33%***	0.77%***	-0.44%***	-0.83%	1.55%***	-0.72%***
% Tds	-0.56%***	0.60%***	-0.05%	-0.36%***	0.70%***	-0.34%***	-0.81%***	1.59%***	-0.77%***
Spread	-0.01%**	0.01%***	0.01%***	-0.01%	0.02%***	0.00%	-0.06%***	0.01%	-0.01%**

APPENDIX 6: EVENT PERIOD SUMMARY STATISTICS

Appendix 6: Event Period Summary Statistics

Appendix 6 provides a comparison of trading activity in the pre-event period (one week before), the event week, and the post event period (one week after). Columns 2, 3, and 4 represent weekly averages. Columns 5, 6, and 7 represent the differences in pre-event and event, event and post-event, and the pre-event and post-event, respectively. Panel A includes tornados, Panel B includes wildfires, and Panel C includes hurricanes/tropical storms. Price is the average daily price for each bond. Dollar volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. The return is the trade-to-trade return. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Pre-Event Weeks	Event Days	Post-Event Weeks	Pre-Event minus Event	Event minus Post-Event	Pre-Event minus Post-Event
Panel A: Tornadoes						
Dollar Volume	$726,875.46	$734,246.51	$708,036.36	$7,371.06	$26,210.15	$18,839.10*
Number of Trades	2.81	2.79	2.78	-0.02*	0.01*	0.03***
Trade Size	$297,770.58	$297,885.97	$296,174.77	$115.39	$1,711.21	$1,595.82
Volatility	1.99%	1.99%	1.99%	0.00%	0.00%	0.01%*
Bid-Ask Spread	1.66%	1.66%	1.66%	0.00%	0.00%	0.00%
Return	0.06%	0.05%	0.04%	0.00**	0.00	0.00
Panel B: Wildfires						
Dollar Volume	$699,504.15	$688,341.71	$672,315.06	-$11,162.44	$16,026.65*	$27,189.09**
Number of Trades	2.78	2.76	2.77	-0.02***	-0.01	0.02**
Trade Size	$279,559.10	$276,645.64	$276,352.72	-$2,913.47	$292.93	$3,206.38
Volatility	2.04%	2.05%	2.03%	0.01%***	0.03%***	0.01%
Bid-Ask Spread	1.70%	1.70%	1.70%	0.00%	0.01%**	0.01%**
Return	0.13%	0.12%	0.11%	0.01**	0.01**	0.02%**
Panel C: Hurricanes/Tropical Storms						
Dollar Volume	$1,069,149.64	$1,009,331.19	$1,063,322.22	-$59,818.45	-$53,991.03	$5,827.42
Number of Trades	3.13	3.14	3.16	0.01	-0.02	-0.03
Trade Size	$435,239.22	$412,455.15	$449,592.50	-$22,784.08	-$37,137.36	-$14,353.28
Volatility	2.53%	2.51%	2.51%	-0.02%	0.00%	0.02%
Bid-Ask Spread	1.94%	1.97%	1.96%	0.02%	-0.01%	-0.02%
Return	0.02%	0.00%	-0.03%	-0.01%	0.03%**	0.04%***

APPENDIX 7: EVENT PERIOD STATISTICS FOR RELATED SECURITIES (TORNADOES)

Appendix 7: Event Period Statistics for Related Securities (Tornadoes)

Appendix 7 presents tornado event period statistics for informationally-related securities. We follow a methodology similar to Chorida, Roll, and Subrahmanyam (2000) in designating informationally-related securities. A bond's informational-related match is all other bonds issued by its issuing state. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. Volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. The return is the trade-to-trade return. The pre-event period is one week before the actual event, and the post event period is one week after the event. The event period is the week of the event. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Security Average	Related Security Average	Difference
Panel A: Spreads			
Pre-Event Week	1.66%	1.85%	-0.18%***
Event Day(s)	1.66%	1.84%	-0.18%***
Post-Event Week	1.66%	1.84%	-0.19%***
F Test	0.20	8.13***	
Panel B: Volume			
Pre-Event Week	$726,875.46	$851,411.22	-$124,535.77***
Event Day(s)	$734,246.51	$842,028.41	-$107,781.89***
Post-Event Week	$708,036.36	$841,069.40	-$133,033.04***
F Test	1.46	11.38***	
Panel C: Number of Trades			
Pre-Event Week	2.81	2.93	-0.12***
Event Day(s)	2.79	2.94	-0.15***
Post-Event Week	2.78	2.93	-0.15***
F Test	3.08**	11.36***	
Panel D: Volatility			
Pre-Event Week	1.99%	1.91%	0.08%***
Event Day(s)	1.99%	1.91%	0.08%***
Post-Event Week	1.99%	1.90%	0.08%***
F Test	0.46	26.32***	
Panel E: Returns			
Pre-Event Week	0.06%	0.22%	-0.16%***
Event Day(s)	0.05%	0.05%	-0.14%***
Post-Event Week	0.04%	0.26%	-0.21%***
F Test	4.16**	3.18**	

APPENDIX 8: EVENT PERIOD STATISTICS FOR RELATED SECURITIES (WILDFIRES)

Appendix 8: Event Period Statistics for Related Securities (Wildfires)

Appendix 8 presents wildfire event period statistics for informationally-related securities. We follow a methodology similar to Chorida, Roll, and Subrahmanyam (2000) in designating informationally-related securities. A bond's informational-related match is all other bonds issued by its issuing state. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. Volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\mathrm{Price}_t}\left(\mathrm{Price}_t^{\mathrm{Max}} - \mathrm{Price}_t^{\mathrm{Min}}\right)$. The return is the trade-to-trade return. The pre-event period is one week before the actual event, and the post event period is one week after the event. The event period is the week of the event. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Security Average	Informationally-Related Security Average	Difference
Panel A: Spreads			
Pre-Event Week	1.70%	1.90%	-0.19%***
Event Day(s)	1.70%	1.89%	-0.19%***
Post-Event Week	1.70%	1.89%	-0.19%***
F Test	0.73	15.92***	
Panel B: Volume			
Pre-Event Week	$699,504.15	$783,932.41	-$84,428.26***
Event Day(s)	$688,341.71	$800,197.52	-$111,855.81***
Post-Event Week	$672,315.06	$807,149.83	-$134,834.76***
F Test	0.75	69.01***	
Panel C: Number of Trades			
Pre-Event Week	2.78	2.91	-0.12***
Event Day(s)	2.76	2.91	-0.15***
Post-Event Week	2.77	2.91	-0.14***
F Test	1.83	2.22	
Panel D: Volatility			
Pre-Event Week	2.04%	1.98%	0.07%***
Event Day(s)	2.05%	1.98%	0.08%***
Post-Event Week	2.03%	1.96%	0.07%***
F Test	4.74***	56.55***	
Panel E: Returns			
Pre-Event Week	0.13%	0.66%	-0.53%***
Event Day(s)	0.12%	0.11%	0.01%***
Post-Event Week	0.11%	0.11%	0.00
F Test	2.28	466.16***	

APPENDIX 9: EVENT PERIOD STATISTICS FOR RELATED SECURITIES (HURRICANES/TROPICAL STORMS)

Appendix 9: Event Period Statistics for Related Securities (Hurricanes/Tropical Storms)

Appendix 9 presents hurricane/tropical storm event period statistics for informationally-related securities. We follow a methodology similar to Chorida, Roll, and Subrahmanyam (2000) in designating informationally-related securities. A bond's informational-related match is all other bonds issued by its issuing state. Bid-ask spread is calculated weekly for each bond by taking the weekly average buy price – weekly average sell price. Volume is the average daily dollar volume for each bond. Number of trades is the average daily trades for each bond. Trade size is the average daily par value traded. Volatility is calculated weekly following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. The return is the trade-to-trade return. The pre-event period is one week before the actual event, and the post event period is one week after the event. The event period is the week of the event. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Security Average	Informationally-Related Security Average	Difference
		Panel A: Spreads	
Pre-Event Week	1.94%	1.90%	0.04%*
Event Day(s)	1.96%	1.90%	0.06%**
Post-Event Week	1.96%	1.94%	0.02%
F Test	0.36	47.01***	
		Panel B: Volume	
Pre-Event Week	$1,069,149.64	$665,079.18	$404,070.46***
Event Day(s)	$1,009,331.19	$671,973.14	$337,358.05***
Post-Event Week	$1,063,322.22	$663,985.11	$399,337.11***
F Test	0.22	0.33	
		Panel C: Number of Trades	
Pre-Event Week	3.13	2.80	0.34***
Event Day(s)	3.14	2.82	0.32***
Post-Event Week	3.16	2.89	0.27***
F Test	0.06	123.01***	
		Panel D: Volatility	
Pre-Event Week	2.53%	1.87%	0.65%***
Event Day(s)	2.51%	1.84%	0.67%***
Post-Event Week	2.51%	1.85%	0.66%***
F Test	0.11	19.84***	
		Panel E: Returns	
Pre-Event Week	0.01%	0.06%	-0.05%***
Event Day(s)	0.00%	0.07%	-0.07%***
Post-Event Week	-0.03%	0.02%	-0.05%***
F Test	4.94***	45.44***	

APPENDIX 10: SPREAD REGRESSIONS

Appendix 10: Spread Regressions

Appendix 10 provides spread regression estimations for 331,429 municipal bonds with 20,553,922 trades from January 2010 – December 2013 for tornados, wildfires, and hurricanes/tropical storms. Regressions are estimated weekly using 3,461,639 bond-week observations. The event period is the week of the event, and the post-event period is the week following the event. The related security is the average bid-ask spread of all other municipal bonds from the same issuing state. The Event Period*Related Security is an interaction term between the event and the related security, and the Post-Event*Related Security is an interaction term between the post-event period and the related security. Dollar volume is the weekly dollar volume for each, and the number of trades is the weekly trades for each bond. Trade size is the average weekly par value traded for each bond. Volatility is calculated following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. Years to maturity is the time to maturity for each bond. Revenue Bond is equal to 1 if the bond is a revenue bond, and zero otherwise. Taxable is equal to 1 if the bond is taxable, and zero otherwise. Top 5 Issuer is equal to 1 if the bond is issued by California, Texas, Pennsylvania, New York, or Illinois. Population is the yearly population for each state provided by the U.S. Census Bureau. The median income is the annual median income of each state, and general fund revenue is the general fund revenue for each state. All regression models are estimated using robust standard errors. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Tornados	Wildfires	Hurricanes/Tropical Storms
	(1)	(2)	(3)
Intercept	-0.0401***	-0.0447***	-0.0477***
	(-6.35)	(-7.11)	(-7.74)
Variables of Interest			
Event Day(s)	-0.0290***	-0.0473***	0.0713
	(-3.04)	(-4.33)	(1.56)
Post-Event Week	-0.0445***	0.0233*	-0.1115**
	(-4.81)	(1.89)	(-2.54)
Related Security	0.2155***	0.2187***	0.2201***
	(41.50)	(41.98)	(42.73)
Event Day(s)*Related Security	0.0181***	0.0247***	-0.0200
	(3.46)	(4.19)	(-0.78)
Post-Event*Related Security	0.0264***	-0.0103	0.0788***
	(5.23)	(-1.57)	(3.44)
Bond/Trading Traits			
Dollar Volume	0.0000	0.0000	0.0000
	(0.96)	(0.96)	(0.96)
Number of Trades	-0.0000	-0.0000	-0.0000
	(-1.02)	(-1.02)	(-1.02)
Trade Size	-0.0000***	-0.0000***	-0.0000***
	(-40.82)	(-40.82)	(-40.82)
Volatility	0.5457***	0.5457***	0.5457***
	(113.89)	(113.88)	(113.88)
Years to Maturity	0.0137***	0.0137***	0.0137***

	(29.29)	(29.29)	(29.29)
Revenue Bond	0.0073***	0.0074***	0.0075***
	(6.60)	(6.70)	(6.74)
Taxable	0.0690***	0.0690***	0.0690***
	(27.98)	(27.97)	(27.99)
Top 5 Issuer	-0.0060***	-0.0056***	-0.0056***
	(-4.50)	(-4.20)	(-4.18)
State Characteristics			
Population	0.0000***	0.0000***	0.0000***
	(2.77)	(3.22)	(3.06)
Median Income	0.0000***	0.0000***	0.0000***
	(18.29)	(18.27)	(18.29)
General Fund Revenue	-0.0000***	-0.0000***	-0.0000***
	(-15.60)	(-16.60)	(-16.40)
R-Squared	68.12%	68.12%	68.12%

APPENDIX 11: VOLATILITY REGRESSIONS

Appendix 11: Volatility Regressions

Appendix 11 provides volatility regression estimations for 331,429 municipal bonds with 20,553,922 trades from January 2010 – December 2013 for tornados, wildfires, and hurricanes/tropical storms. Regressions are estimated weekly using 3,461,639 bond-week observations. The event period is the week of the event, and the post-event period is the week following the event. The related security is the average volatility of all other municipal bonds from the same issuing state. The Event Period*Related Security is an interaction term between the event and the related security, and the Post-Event*Related Security is an interaction term between the post-event period and the related security. Dollar volume is the weekly dollar volume for each, and the number of trades is the weekly trades for each bond. Trade size is the average weekly par value traded for each bond. Volatility is calculated following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. Years to maturity is the time to maturity for each bond. Revenue Bond is equal to 1 if the bond is a revenue bond, and zero otherwise. Taxable is equal to 1 if the bond is taxable, and zero otherwise. Top 5 Issuer is equal to 1 if the bond is issued by California, Texas, Pennsylvania, New York, or Illinois. Population is the yearly population for each state provided by the U.S. Census Bureau. The median income is the annual median income of each state. All regression models are estimated using bond-clustered standard errors. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Tornados (1)	Wildfires (2)	Hurricanes/Tropical Storms (3)
Intercept	-0.3850***	-0.4028***	-0.4182***
	(-3.40)	(-3.49)	(-3.58)
Variables of Interest			
Event Day(s)	-0.1937***	-0.0925	-0.1976
	(-4.10)	(-1.02)	(-1.08)
Post-Event Week	-0.0595	-0.0967**	0.1948*
	(-1.20)	(-2.11)	(1.69)
Related Security	0.7571***	0.7624***	0.7693***
	(27.14)	(26.74)	(27.66)
Event Day(s)*Related Security	0.0924***	0.0419	0.1092
	(3.91)	(0.83)	(1.07)
Post-Event*Related Security	0.0241	0.0380	-0.0963
	(0.89)	(1.59)	(-1.61)
Bond/Trading Traits			
Dollar Volume	-0.0000	-0.0000	-0.0000
	(-1.09)	(-1.09)	(-1.09)
Number of Trades	0.0000	0.0000	0.0000
	(1.08)	(1.08)	(1.08)
Trade Size	-0.0000***	-0.0000***	-0.0000***
	(-22.27)	(-22.29)	(-22.27)
Years to Maturity	0.0974***	0.0974***	0.0974***
	(53.83)	(53.78)	(53.69)
Revenue Bond	-0.0410	-0.0409	-0.0414

	(-1.29)	(-1.29)	(-1.32)
Taxable	0.2457***	0.2458***	0.2458***
	(4.32)	(4.33)	(4.33)
Top 5 Issuer	0.0171	0.0138	0.0153
	(0.54)	(0.41)	(0.45)
State Characteristics			
Population	0.0000	0.0000	0.0000
	(1.42)	(1.31)	(1.30)
Median Income	-0.0000*	-0.0000*	-0.0000*
	(-1.86)	(-1.77)	(-1.72)
R-Squared	23.19%	23.19%	23.18%

APPENDIX 12: MOST ACTIVE AND LEAST ACTIVE BONDS

Appendix 12: Most Active and Least Active Bonds

Appendix 12 models dollar volume for the most active quartile of bonds and the least active quartile of bonds. The analysis uses 865,628 bond-week observations for the most active bonds, and 875,118 bond-week observations for the least active bonds. The event period is the week of the event, and the post-event period is the week following the event. The related security is the average dollar volume of all other municipal bonds from the same issuing state. The Event Period*Related Security is an interaction term between the event and the related security, and the Post-Event*Related Security is an interaction term between the post-event period and the related security. Years to maturity is the time to maturity for each bond. Revenue Bond is equal to 1 if the bond is a revenue bond, and zero otherwise. Taxable is equal to 1 if the bond is taxable, and zero otherwise. Top 5 Issuer is equal to 1 if the bond is issued by California, Texas, Pennsylvania, New York, or Illinois. Population is the yearly population for each state provided by the U.S. Census Bureau. The median income is the annual median income of each state. All regression models are estimated using bond-clustered standard errors. Significance is indicated at the 1%, 5%, and 10% levels with ***, ***, and *.

	Tornados		Wildfires		Hurricanes/Tropical Storms	
	Most Active	Least Active	Most Active	Least Active	Most Active	Least Active
Intercept	0.00***	51,122***	0.00***	51,292***	0.00***	51,054***
	(22.03)	(181.59)	(20.03)	(183.77)	(-20.69)	(185.24)
Variables of Interest						
Event Day(s)	511,610,345	-145.48	$750,231,335	-332.08	12,030,119,470***	833.75
	(0.54)	(-0.68)	(1.13)	(-1.59)	(25.49)	(1.28)
Post-Event Week	13,466,422,678***	271.00	12,986,073,335***	-1,170.64***	11,812,405,815***	1,939.71***
	(31.93)	(0.99)	(38.49)	(-5.28)	(25.06)	(-2.80)
Related Security	1,261.96***	0.0023***	1,257.65***	0.0023***	1,255.98***	0.0024***
	(29.12)	(42.72)	(26.73)	(44.45)	(26.92)	(48.86)
Event Day(s)*Related	-42.84	0.00	-4.78	0.0004***	-1,171.66***	0.0007**
Security	(-0.50)	(0.27)	(-0.07)	(3.97)	(-25.32)	(2.33)
	-1,195.18***	0.0002*	-1,192.17***	0.0008***	-1,154.03***	0.0016***
Post-Event*Related Security	(-31.30)	(-1.73)	(-37.87)	(8.11)	(-24.83)	(5.07)
Bond/Trading Traits	-507,631,660***	-456.80***	-534,565,101***	-457.87***	-579,497,057***	-457.10***
Years to Maturity	(-26.91)	(-114.81)	(-25.23)	(-115.16)	(-24.25)	(-114.89)
	121,564,835	-586.02***	421,592,760**	-589.70***	394,313,548**	-585.96***
Revenue Bond	(0.64)	(-7.42)	(2.17)	(-7.47)	(2.06)	(-7.43)
	-4,748,091,818***	-	-528,577,6185***	-5,278.20***	-566,800,6097***	-5,273.66***
Taxable	(-15.88)	5,275.37***	(-15.57)	(-42.57)	(-15.89)	(-42.52)
	-4,412,711,678***	(-42.55)	-4,419,877,833***	-1,725.37***	-5,010,897,536***	-1,735.26***
Top 5 Issuer	(-23.61)	-	(-20.82)	(-17.16)	(-21.85)	(-17.25)
		1,735.22***				
State Characteristics	82.48***	(-17.28)	89.64***	0.00***	106.61***	0.0001***

Population	(10.80)	0.0001***	(9.64)	(19.26)	(12.70)	(22.10)
	113,664***	(22.15)	125,498***	0.0944***	133,292***	0.0950***
Median Income	(16.29)	0.0932***	(15.90)	(18.96)	(16.31)	(19.09)
		(18.67)				
R-Squared	96.91%	3.79%	96.70%	3.82%	96.58%	3.80%

APPENDIX A: INDIVIDUAL BONDS TRADED, BY YEAR

Appendix A: Individual Bonds Traded, By Year

Each column includes the unique number of bonds traded each year for each state in the sample period 2010 – 2013. The last column is the number of unique bonds traded over the course of the full sample for each state.

State	2010	2011	2012	2013	Full Sample
AK	579	579	553	621	1,253
AL	1,391	1,454	1,516	1,763	3,270
AR	806	747	891	937	2,067
AZ	2,801	2,995	2,690	3,033	5,380
CA	24,692	24,888	25,683	25,791	49,234
CO	2,643	2,706	2,564	2,954	5,650
CT	2,626	2,606	2,405	2,846	5,646
DC	353	402	438	547	753
DE	1,188	1,201	1,096	1,198	2,063
FL	8,548	8,649	7,700	7,962	15,011
GA	3,323	3,721	3,423	3,722	6,809
HI	812	866	809	887	1,521
IA	674	736	701	840	1,761
ID	401	416	372	444	877
IL	9,504	9,406	8,831	9,453	18,576
IN	4,883	4,951	4,478	4,834	10,287
KS	1,544	1,508	1,410	1,709	3,489
KY	1,078	1,109	1,108	1,244	2,546
LA	922	884	937	1,085	2,038
MA	3,812	3,900	3,557	3,870	7,711
MD	1,868	2,056	1,958	2,228	3,901
ME	628	600	633	748	1,511
MI	4,884	4,659	4,126	4,338	9,398
MN	2,340	2,318	2,153	2,333	5,196
MO	2,232	2,166	1,981	2,315	4,732
MS	1,414	1,392	1,334	1,522	2,902
MT	280	254	291	345	711
NC	4,498	4,658	4,334	5,081	9,524
ND	188	200	210	283	566
NE	753	770	792	861	1,717
NH	589	594	593	651	1,324
NJ	6,642	6,951	6,251	6,652	13,840
NM	674	669	632	774	1,475
NV	926	913	804	871	1,560
NY	13,871	14,337	13,505	14,758	27,550
OH	5,274	5,488	4,959	5,720	11,281
OK	968	1,034	912	1,108	2,212
OR	2,517	2,730	2,458	2,932	5,613
PA	9,087	9,088	8,290	9,130	18,877
RI	603	661	544	648	1,399
SC	2,708	2,904	2,740	2,970	5,728
SD	206	221	222	264	540
TN	1,405	1,333	1,361	1,429	2,884
TX	12,408	12,856	12,516	14,358	28,017
UT	895	946	832	1,034	1,939
VA	3,377	3,517	3,428	4,054	7,184
VT	70	92	98	64	175
WA	4,285	4,528	4,254	4,929	8,845
WI	1,774	1,762	1,655	1,909	3,929
WV	209	200	179	212	420
WY	86	95	102	157	266

APPENDIX B: NATURAL DISASTER EVENTS, BY YEAR

Appendix B: Natural Disaster Events, By Year

Appendix B includes information on the number of natural disasters and the types of natural disasters that occur each year in the sample period 2010 – 2013. Natural disaster information is obtained from the National Climactic Data Center's website.

Disaster Type	2010	2011	2012	2013	All Years
Tornados	308	328	268	268	1,172
Wildfires	273	836	565	203	1,877
Hurricanes/Tropical Storms	7	21	13	5	46
Total	588	1,185	846	476	3,095

PART 3: MUNICIPAL BOND TRADING AND POLITICAL SCANDALS

INTRODUCTION

Research details that investors profit from local investment choices; for example, Ivkovic and Weisbenner (2005) show that local investments outperform non-local investments by 3.2%. Ivkovic and Weisbenner conclude the performance of local investments is driven by superior knowledge of local firms. Local investors may choose to invest not only in equities, but also in municipal bonds. One reason the municipal bond market is attractive to local investors is the tax advantages it offers. The knowledge base of local investors may not be limited to surrounding firms; it may also extend to local governments. Scott (2006) details that 69% of residents interact with their local mayor and 78% interact with their local city council. Scott also shows that 63% of local residents have access to city budgets and financial reports. Investors are able to garner information about local governments through these interactions.

Documenting the municipal bond market's reaction to government misconduct provides information as to how and when the bond market incorporates information. There are three reasons why studying the municipal bond market provides value. First, focusing on the municipal bond market allows us to study a market dominated by local retail investors, as documented by Green, Hollifield, and Schurhoff (2007). Retail traders may be both the traders most affected by the wrongdoing and the traders with the most information about the misconduct itself. Scott (2006) details that local residents often interact with local officials and have access to city financial reports. Retail trades may aid in price discovery both during and after announcements of government misconduct, and we are able to determine what type(s) of trades contribute to price discovery by dividing our sample into small trades and large trades.

Second, the municipal bond market does not offer the same transparency or information availability as the equity market. Municipalities do not release quarterly earnings reports like public firms, and many municipalities that issue bonds are small. Information is not always readily available about municipalities given the lack of transparency in the market, and it is possible that news of government officials' wrongdoing may serve as one of the only sources of information about the quality of government in municipalities. Additionally, information about municipal securities may be hard to disseminate and absorb; each municipality can have multiple issues of bonds outstanding. For example, municipal bonds tend to be issued in a series, and some of the larger issues contain as many as thirty bonds of various maturities and coupon rates (Green, Hollified, and Schurhoff, 2007). It may be difficult to decipher information about such a large amount of securities, especially compared to the equities market where investors need to be informed about only one class or type of stock per firm.

Third, the municipal bond market is different from the equities market. There is no exchange fostering pre-trade transparency in the municipal bond market, and there is also no quote or order book that traders can use to guarantee fair prices on municipal bonds. In fact, previous literature documents that large amounts of price dispersion exist in the municipal bond market, even after post trade transparency is implemented (Schultz, 2012). Bond markets in general are also less efficient than the equities market. We provide evidence regarding the municipal bond market's efficiency and quality by studying bond trading activity before, during, and after announcements regarding government officials and their misconduct.

RELATED LITERATURE

Research exists on the overall market quality of the municipal bond market. For example, Harris and Piwowar (2007) show that trading costs are inversely related to trade size and that the municipal bond market is illiquid. Green, Li, and Schurhoff (2010) provide evidence regarding municipal bond pricing efficiency and focus on profit-motivated dealers and their behavior. The authors detail that municipal bond dealers are quick to incorporate information that results in price increases, but are slow to react to information that negatively influences bond prices. While Green, Li, and Schurhoff focus on how dealers react to macroeconomic news, this paper focuses on how individual municipal bond traders react to news. Specifically, this paper focuses on how (and if) municipal bond traders react to wrongdoing by local political officials.

Local traders, in general, not only invest locally but also make informed local investment decisions. Ivkovic and Weisbenner (2005) find that local investors allocate roughly 30% of their investment portfolio to local firms. The local investments chosen outperform non-local investments by 3.2%. Based on the outperformance, the authors conclude that local traders choose their investments based on knowledge of local firms. The tendency to invest locally also extends to mutual fund managers. Coval and Moskowitz (1999, 2001) show mutual fund managers invest in companies geographically close to the manager's location and the local investments earn a positive 2.67% abnormal return per year. Again, the return on the investment implies superior knowledge of local firms.

Butler, Fauver, and Mortal (2009) provide a study of political integrity in the municipal bond underwriting market. While Butler, Fauver, and Mortal do not focus on government misbehavior, the authors focus on a related topic. Specifically, they focus on the effect of political integrity and corruption on the issuance of municipal bonds. Butler, Fauver, and Mortal study the municipal bond underwriting market and describe how it is historically fraught with corruption due to a pay-to-play practice; basically, investment banks bid on underwriting business through their campaign contributions to local government officials. The authors use per-capita federal convictions as a proxy for local corruption. In general, they find that credit risk and corruption are correlated. Specifically, states with higher corruption tend to issue, on average, riskier bonds (based on credit ratings) and corrupt states tend to pay higher yields to maturity. The authors do not provide any evidence regarding corruption and local bond trader behavior, however. This paper adds to the Butler, Fauver, and Mortal paper by showing how municipal bond traders react to wrongdoing by local government officials.

HYPOTHESES

Butler, Fauver, and Mortal (2009) establish a link between municipal bonds and state corruption. Butler, Fauver, and Mortal do not provide evidence regarding investor reaction to political wrongdoing, nor do they examine municipal bond trading. In this paper, we focus on municipal bond trading activity and its relation to governmental misconduct. First, we focus on the municipal bond spread. Butler, Fauver, and Mortal detail that corrupt states tend to issue riskier bonds, which could lead to higher spreads for traders. In addition, dealers may adjust the bond spread following a political scandal to compensate for informed traders. We present the following hypothesis:

H1: Municipal bond spread increases following a local scandal.

Second, we focus on trading activity following the disclosure of government misconduct. Information will disseminate into the market following a scandal. McInish and Wood (1992) utilize volume as a measure of information. As information flows into the market, we expect both trading volume and the number of trades will increase. We present the following hypotheses:

H2: Municipal bond volume increases following a local political scandal.

H3: The number of trades in municipal bond issues increases following a local political scandal.

Third, we focus on the activity following a political scandal. In the bond market, trade size is an indicator of whether a trade is an institutional or a retail trade. Ronen and Tavy (2013) detail that small bond trades are almost always retail trades, whereas larger trades are institutions. Due to the tax advantages offered to municipal bond holders, municipal bond retail trades are likely local investors (Green, Hollifield, and Schurhoff, 2007). State residents are offered tax advantages on municipal bonds, but only for bonds issued in the state in which they reside. Focusing on how (or if) trade size changes as traders share their information following a political scandal enables us to determine whether institutions, local retail investors, or perhaps both are changing their trading activity following a scandal. We present the following hypothesis:

H4: There is a direct relation between the average municipal bond trade size and the occurrence of a political scandal.

Research supports both institutions and local traders as informed traders. Ivkovic and Weisbenner (2005) determine that local investments tend to outperform non-local investments by over 3%, leading the authors to conclude that local investors possess superior knowledge of local firms. Mutual fund managers are shown to invest in local companies and to earn abnormal returns on local investments (Coval and Moskowitz, 1999, 2001). Institutions are also shown to provide information to the market. Chakravarty (2001) details that institutions make up a majority of the price impact of medium-sized equity trades. It is possible that both retail investors and institutions provide information to the municipal bond market following a political scandal. Ivkovic and Weisbenner and Coval and Moskowitz utilize abnormal returns as a measure of information, while Chakravarty uses price impact to determine that institutions provide information to the market. By using both returns and price impact, we are able to show which size investors earns abnormal returns following government wrongdoing, and also which size investors contributes to price contribution. We propose the following hypotheses:

H5A: There is a direct relation between abnormal returns in the municipal bond market and the occurrence of a local political scandal.

H5B: There is a direction relation between weighted price contribution in the municipal bond market and the occurrence of a local political scandal.

DATA AND SAMPLE SELECTION

We use municipal bond transaction data for January 2006 through December 2013 from the Municipal Securities Rulemaking Board (MSRB). The MSRB municipal bond database includes all trades by registered broker-dealers. Each trade is identified as a dealer purchase from a customer, dealer sale to a customer, or interdealer trade, and each trade record includes the CUSIP, security information, coupon, yield, par value traded, and price. The data initially includes 78,640,003 bond transactions. We require bonds in the sample to trade nine times each year (Edwards, Harris, and Piwowar, 2007)[1], which removes 10,372,314 trades from the sample. We also require bonds in the sample to trade at prices above 25% of par in order to remove municipalities close to bankruptcy or default, and we remove transactions with data entry errors/missing values. These two deletions further reduce our sample by 217,332 trades.

After constructing weekly spread measures, we lose an additional 28,948,700 observations. Our final data sample includes 39,105,657 trades in 481,365 municipal bonds issued by the municipalities in all fifty states in the United States. We obtain each bond's issuing state and whether a bond is general obligation or revenue from the MSRB's Electronic Municipal Market Access (EMMA) website. We collect data on state population and income from the United States Census Burea, and we obtain information on individual state financials from the Fiscal Survey of the States compiled by the State Governor's Association.

[1] Harris and Piwowar (2006) study transactions costs in the municipal bond market and require bonds in their sample to trade at least six times. We follow Edwards et al (2007) and use a more restrictive requirement (nine times each year) to control for potential nonsynchronous trading, given the illiquidity of the municipal bond market. We replicate each table using the Harris and Piwowar restriction, and the results are qualitatively similar.

We are interested in the way announcements regarding state and local government officials' wrongdoing influence municipal bond trading. We utilize the Department of Justice's Criminal Division reports on the illegal activity of government officials as well as an internet based search to find news reports of officials and their wrongdoing. We acquire both announcement of Justice Department investigations, indictments and trial verdict outcomes from the Justice Department reports, and we utilize an internet search to find the first news date of the illegal or questionable activity. In our analysis, we focus on three types of events: first reported news days, indictment announcement days, and trial verdict announcement days. We collect 115 individual events of government officials' misconduct, illegal activity, or in some cases, scandal.[2]

[2] The types of misconduct in our sample include bribery, money laundering, domestic/sexual abuse, assault, illegal wire tampering, and child pornography charges. The officials in the sample are state legislature members, state governors, state lieutenant governors, state secretaries, and members of US Congress.

THE MUNICIPAL BOND MARKET DESCRIPTION

Several types of government entities issue municipal bonds, including state and local governments, electric companies, schools, and hospitals. Municipal bonds are not regulated by the Securities and Exchange Commission and instead are governed by the MSRB. The market itself is highly fragmented and opaque (Harris and Piwowar, 2007; and Green, Li, and Schurhoff, 2010), and trading occurs in an over the counter setting through dealers. The MSRB website EMMA provides information about the municipal bond market, including post-trade information for municipal bonds. Trades are reported to the MSRB's real-time transaction reporting system (RTRS) within 15 minutes of the trade execution, and the trades then are posted publicly to the EMMA website. Real time trade reporting includes real-time prices for most trades occurring after January 31, 2005.

Appendix 1 supplies information about the sample of municipal bond trades. Overall, the majority of trading occurs in bonds with more than ten years to maturity (71.34%), regardless of whether or not any type of announcement occurs about government officials and their misconduct. The municipal bond market is dominated by small trades. Roughly 72% of trades are less than $100,000 in size. The majority of bond trades execute at prices above par (53.59%) and occur in bonds issued by the top five bond issuing states (California, Texas, New York, Florida, and Pennsylvania) during our sample period. Dealer sales account for the largest portion of trading as compared to both interdealer trades and dealer purchases.

In Panel B, we separate the event days into three categories: news days, indictment announcement days, and trial verdict announcement days. News days appear to have the most large trades (29.57%), while indictment announcement days appear to have the largest portion of small trades (74.17%). Small trades are trades less than $100,000, and large trades are trades greater than $100,000.[3] We detail general summary statistics about the sample in Appendix 2. Panel A shows a summary of all bonds in the sample. The average municipal bond trade size is around $333,000, and the average daily dollar volume for municipal bonds is over $904,000. Municipal bonds trade an average of three times per day with an average bid-ask spread of 1.45%. The bonds in the sample have an average of nearly ten years to maturity. Panel B details the bonds issued by the top five bond issuing states: California, Texas, New York, Florida, and Pennsylvania. Overall, the summary statistics for the bonds issued by the top five issuing states are quite similar to those for the full sample of 481,365 bonds.

[3] We follow Edwards, Harris, and Piwowar (2007) in classifying our trade sizes. We replicate all tables using various trade size values in determining large and small trade sizes. The results are qualitatively similar regardless of the method used.

RESULTS

First, we are interested in what effect, if any, announcements regarding state officials and their misconduct have on municipal bond trading. We test for differences in event days and non-event days. We initially define an event day as the day when either a news report announcement, indictment announcement, or a trial verdict announcement is made. The announcement must relate to the government officials' misconduct, wrongdoing, or scandal, and it is the first report of its kind (ie, first news day, report day, etc). Non-event days are all trading days without any such announcement. We present results for our initial analysis in Appendix 3. We find the average municipal bond trade size is larger on event days than non-event days. The difference in trade size between the event and non-event is nearly $60,000. We also find that dollar volume is greater on event days than all other trading days. Event days influence spreads, leading to a 0.02% increase in trading costs (1.72% on event days compared to 1.70% on other trading days). There are no differences in the number of trades or returns between event days and non-event days.

We graph the relation between event days and non-event days in Figure 1. Figure 1 shows total dollar volume as well as both large trade dollar volume and small trade dollar volume during the five trading days leading up to the announcement, the day of the announcement, and the five trading days following the announcement. Between days negative three and three, it appears that total volume and large trade dollar volume peak on the event day and then decline over the next few trading days. Small trade volume appears unaffected by the announcements about misconduct.

Figure 2 shows the relation between event days, non-event days, and the bid-ask spread. In Figure 2, we see a steep increase in spreads beginning on day negative four. The increase in spreads continues through the event day and the following trading days. Spreads appear to decline and level off around day four following the event. Overall, the evidence in Appendix 3, Figure 1, and Figure 2 gives an indication that announcements about government officials and their wrongdoing influence municipal bond trading.

We further our analysis by dividing the sample of trades in based on the type of announcement that occurs (news days, indictment announcement days, and trial verdict announcement days) in Appendix 4. Panel A includes news announcement days. The average municipal bond trade size is about $107,000 larger on news announcement days than other trading days. The corresponding average daily dollar volume is higher on news announcement days as well. Dollar volume is around $1,700,000 on news announcement days, but dollar volume is roughly $1,500,000 on other trading days. The difference in volume is nearly $200,000. However, we find no differences in returns, the number of trades, or spreads between news announcement days and non-announcement days.

Panel B provides the analysis of indictment days. Spreads are higher on indictment announcement days than non-announcement days. Specifically, spreads are 1.81% the day indictments are announced compared to 1.78% on other trading days. Municipal bonds trade more often on indictment announcement days as well, about 3.25 trades execute on indictment days compared to 3.05 trades on other trading days. Panel C provides statistics for trial verdict announcement days. The only different in trading activity on trial verdict days relates to spreads. We find that spreads are 0.05% higher on trial verdict days than on days when no announcement occurs regarding government official misconduct.

In the previous appendices, our analysis focuses on the differences in all trading on the various event days (and non-event days) that relate to announcements of government official misconduct. Now, we attempt to isolate the type of trading activity based on trade size. We follow Edwards, Harris, and Piwowar (2007) in classifying trades. We categorize trades as "large" if they exceed $100,000, and we classify trades as small if they are less than $100,000 in size. Small trades are generally viewed as retail trades in the bond market, and large trades are labeled institutions (Ronen and Zhou, 2013; and Edwards, Harris, and Piwowar, 2007). We attempt to isolate "who" changes trading activity when announcements about government misconduct or scandal occur by dividing our sample by trade size.

Appendix 5 provides our first analysis based on trade size. Panel A includes small trades, and Panel B includes large trades. Both the average trade size and dollar volume are larger on event days than other trading days for small trades. Small trades are about $300 larger on event days, whereas dollar volume is nearly $3,000 higher on event days. We also find that slightly more small trades occur on event days than non-event days; however, small trades account for similar proportions of volume and trades on both event day and other trading days.

The results for larger trades are shown in Panel B. Large trades earn positive returns on event days, while non-event day returns for large trades are negative. Large trade dollar volume increases by roughly $180,000 when an announcement about government officials' wrongdoing is made. The average large trade is roughly $1,400,000 on event days, which is around $115,000 larger than the average large trade on other trading days. We also find that spreads are 0.04% higher on event days for large trades. We find no differences in either the number of trades or the proportion of volume (trades) for which large trades account between event and non-event days.

We continue our trade size analysis in Appendix 6. We divide the sample based on three types of events (news announcement days, indictment announcement days, and trial verdict announcement days) and based on trade size (large trades versus small trades). Panel A provides statistics regarding event days (divided by type of event) and trade sizes, while Panel B provides information regarding non-event days and trade sizes. Panel C shows difference estimates between the two trading days and between trade sizes. Small trades are trades less than $100,000, and large trades are trades greater than $100,000. Generally, it appears that small trades on news announcement days and small trades on non-news days are qualitatively similar.

Trade sizes hover around $30,000 on both days, and dollar volume is about $60,000 on both news and non-news days. Spreads, the number of trades, and returns are also similar for small trades on news announcement and non-announcement days. Small trades account for similar proportions of dollar volume and trading, regardless of it being an event day. There are differences between large trades on news and large trades on non-news days. Large trades earn positive returns on news event days; the returns to large trades are 0.0012% higher on news event days. Large trades are also roughly $200,000 greater in size on news event days and large trade volume is about $312,000 higher.

We document several differences between indictment announcement days and days without indictment announcements. Small trade dollar volume is roughly $72,000 on indictment announcement days, but small trade volume is only around $65,500 on non-event days. The difference is nearly $7,000. Small trades occur slightly more often on indictment announcement days than other trading days, and make up 0.76% more of the total number of trades. Large trades are more expensive to trade on indictment announcement days. Specifically, large trade spreads are 1.10% on the days indictments are announced, but only 1.04% on other trading days.

We also find that large trades account for a smaller portion of volume and a smaller portion of trades on indictment announcement days.

Lastly, we analyze trading activity on trial verdict announcement days and non-announcement days. The majority of trading activity (for both small and large trades) is similar on trial verdict announcement days and non-announcement days. Trade sizes for small trades are around $30,000 on both verdict days and non-verdict days, and large trades are roughly $1,200,000 to $1,400,000 on both types of days. Returns and the number of trades are similar for both large and small trades regardless of whether it is a verdict announcement day or not. Spreads, however, are larger on trial verdict days than other trading days. The average spread for small trades is 2.03% on non-verdict days, but spreads increase to 2.07% on verdict announcement days (a difference of 0.04%). The same is true for large trades; spreads are 0.07% larger on trial verdict announcement days than other trading days.

In the previous appendices, we document the influence that announcements about government officials and their wrongdoing have on municipal bonds' trading activity. We attempt to further isolate the influence these announcements have on trading activity in this section. Our first regression models estimate the bid-ask spread. We follow Harris, Edwards, and Piwowar (2007) in our regression model. Our main variables of interest are the event day and the post event day variables. The event day variable is equal to one when news, indictment, or verdict announcements are made regarding misconduct. The post-event day variable is equal to one during the five trading days following the announcement about misconduct. We control for the overall quality of each state's government with the number of Justice Department convictions (of state officials) from the previous year. We also control for other factors shown to influence spreads: dollar volume, number of trades, trade size, volatility, and years to maturity.

We control for whether a bond is taxable, and whether it is a revenue or general obligation bond. Lastly, we control for the general financial environment in each state with the median population income and general fund revenue.

We find a positive relation between spreads and news event announcements, indictment announcements, and trial verdict announcements. Spreads are 0.06% higher on event days than the five days prior to the news announcement of wrongdoing. Spreads continue to remain elevated the five days following the announcement/news event. On news event days, spreads are 0.04% higher than spreads during the prior five trading days. Spreads continue to remain high the five days following the news announcement and are 0.05% higher than the pre-event period. The results are similar for indictment announcements. Spreads are about 0.04% higher on indictment announcement days than spreads during the five days leading up to the announcement (which is similar to the news announcement results). After the indictment announcement, spreads are still higher by 0.03% (compared to the week before the indictment is announced). Trial verdict announcements appear to influence spreads more than news days or indictment announcements. Spreads are 0.13% higher on trial verdict announcement days than prior to the announcement. Following the announcements, spreads are still higher than the pre-announcement period (by about 0.07%). A negative relation exists between spreads and the lagged government officials' convictions measure. It is possible that convictions serve a positive purpose for municipal bonds (and municipalities). Convictions in one year could serve as a "house cleaning" mechanism for governments that leads to less corruption in state governments in general.

Next, we consider the relation between municipal bond dollar volume and events related to government officials' misconduct. We divide dollar volume into two categories in our analysis: small trade dollar volume and large trade dollar volume. Small trade dollar volume is the sum of all trades less than $100,000 in size, while large trade dollar volume includes trades over $100,000 in size. Given that small trades are likely retail investors and that small municipal bond trades are likely local investors (Green, Hollifield, and Schurhoff, 2010), examining volume in these two group provides insight as to whether local traders or institutions respond to political scandal or misconduct.

Appendix 8 presents the municipal bond volume regression estimations. We estimate separate regression models based on news event days, indictment announcement days, and trial verdict announcement days. We find that volume generally declines on the day of the event and the five trading days following the event for all three types of announcements. Small trade dollar volume falls by roughly $1,200,000 for news announcement days,. Small trade volume continues to fall during the five trading days following the announcement day and is nearly $1,000,000 lower after the news of government officials' misconduct. Large dollar volume declines in a similar manner on news announcement days and the post announcement period. Specifically, large trade dollar volume falls by around $64,000,000 on the news announcement days and continues to be lower the five subsequent trading days.

We also find a negative relation between small (and large) dollar volume and indictment announcement days. Small dollar volume is nearly $700,000 lower on the days indictments are announced compared to the five trading days leading up to the indictment. Small dollar volume continues to be lower after the indictment is announced (as compared to pre-announcement levels). We find the same results for large trade dollar volume both on and following indictment announcements, albeit the results appear to be larger in magnitude. Lastly, we document a relation between trial verdict announcements and small (large) dollar volume. On verdict announcement days, small trade dollar volume falls by over $145,000. Small trade dollar volume continues to decline the week following the trial verdict announcement. Large trade volume also falls on the verdict announcement days and the subsequent five trading days.

Small trades in the bond market are typically classified as retail trades, and large trades in the bond market are labeled institutions (Ronen and Zhou, 2013; and Edwards, Harris, and Piwowar, 2007). Other research also discusses whether small or large trades (in general) provide information to the market.[4] We seek to determine which trade sizes and which trade types provide information to the municipal bond market. We do so by calculating the weighted price contribution of trades following Barclay and Warner (1993).[5] The results for WPC are shown in Appendix 9. Panel A provides estimates divided by trade size, and Panel B divides the sample by trade type (dealer purchases, dealer sales, and interdealer trades).

Large trades account for the majority of price contribution on event days. Specifically, large trades provide 61% of price contribution on event days, and small trades provide the corresponding 39%. The price contribution is different on non-event days. Small trades provide the majority of price contribution on days no announcement is made regarding government officials and their wrongdoing. We further our analysis of price contribution by dividing the sample by trader types. Overall, we find that dealer purchases account for 53% of price contribution on event days, 18% more than on non-event days. Dealer sales account for less WPC on event days than non-event days (35% compared to 49%). Interdealer trades provide the smallest amount of price contribution, regardless of whether it is an event day or a non-event

[4] Studies exist supporting both small and large trades, both retail and institutional investors, and local traders as providing information to the market. Examples include Barclay and Warner (1993); Coval and Moskowitz (1999, 2001); Ivkovic and Weisbenner (2005); Barber, Odean, and Zhu (2009); and Boehmer and Kelley (2009).

[5] We follow Barclay and Warner (1993) in calculating weighted price contribution. Other studies also utilize the weighted price contribution metric and provide a thorough discussion of the methodology. Other studies include Barclay and Warner (1993); Barclay and Hendershott (2003); Jiang, Likitapiwat, and McInish (2013); and O'Hara and Yao (2014).

day. Interdealer trades contribute 16% to price discovery on non-event days, but their contribution falls to 12% on event days.

CONCLUSION

We document how municipal bond traders react to wrongdoing by government officials. We use 115 individual events of government officials' misconduct to test the efficiency of the municipal bond market, and our study specifically focuses on the municipal bond market's reaction to information using news announcements, indictment announcements, and trial verdict announcements. First, we focus on documenting differences in event days and non-event days. Event days are any day on which a news announcement, indictment announcement, or trial verdict announcement occurs; non-event days are all other trading days. Our results indicate there are differences in municipal bond trading between event days and non-event days. Trade sizes, dollar volume, and spreads are larger on event days compared to non-event days. We divide the sample by types of events (news announcements, indictment announcements, and trial verdict announcements), and we continue to find differences between event and non-event days. For both indictment announcement days and trial verdict announcement days, spreads are higher on the announcement day than on other trading days. We further our analysis by dividing the sample by small and large trades; both large and small trade volume increases on event days.

Second, we model both spreads and bond volume in an effort isolate the effect announcements of wrongdoing have on both event days and the five trading days following the event. Spreads are 0.06% higher during event days than during the five preceding trading days, and spreads remain elevated following the event. We also use regression analysis to determine what effect events have on small trade and large trade volume. Overall, we find that both small and large trade volume declines on event days and the following five trading days (compared to the five days leading up to the announcement).

Third, we study price discovery in the municipal bond market in an effort to document what type(s) of trades provide information to the municipal bond market on event days and also how price discovery may differ on event days compared to non-event days. Large trades provide 61% of price contribution on event days, while small trades account for the largest portion of price discovery on other trading days. Overall, our study provides valuable information regarding the effect government officials and their misconduct can have on both the quality and the trading activity in the municipal bond market.

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APPENDICES

APPENDIX 1: MUNICIPAL BOND TRANSACTIONS CHARACTERISTICS

Appendix 1: Municipal Bond Transaction Characteristics

Appendix 1 provides transaction summary characteristics for all municipal bond trades that trade more than nine times each year from 2006 to 2013. The sample includes 481,365 bonds issued by municipalities in the United States and 39,105,657 executed trades. Panel A provides information for the full sample of bonds. Event days are any trading day when an announcement (news, indictment, or trial verdict) is first reported regarding state and government official's misconduct, and non-event days are all other trading days. Panel B divides the event days by type of event. News day is the first day that news of a government officials' misconduct is reported. Indictment days are the days that indictment announcements are made and reported in the press for government officials' misconduct. Trial verdict days are the days that news of the trial's outcome for officials' wrongdoing is reported.

	All Trading Days	Event Days	Non-Event Days
Panel A: All Bond Trades			
% trades in taxable bonds	5.85%	5.69%	5.85%
% trades in bonds with less than 1 year to maturity	2.58%	2.60%	2.57%
% trades in bonds with 1 to 10 years to maturity	26.08%	25.59%	26.08%
% trades in bonds with more than 10 years to maturity	71.34%	71.81%	71.34%
% trades less than or equal to $100,000	72.19%	72.47%	72.18%
% trades greater than $100,000	27.81%	27.53%	27.82%
% trades of premium bonds	53.59%	49.44%	53.60%
% trades of discount bonds	29.19%	35.55%	29.17%
% trades at par	17.22%	15.01%	17.22%
% trades in Top Five Issuers	46.28%	79.47%	46.22%
% Interdealer Trades	28.08%	28.61%	28.08%
% Dealer Sales	45.74%	44.79%	45.74%
% Dealer Purchases	26.18%	26.60%	26.18%
Panel B: Bond Trades by Type of Event Day			
	News Days	Indictment Days	Trail Verdict Days
% trades in taxable bonds	6.12%	4.89%	6.51%
% trades in bonds with less than 1 year to maturity	2.46%	2.76%	2.57%
% trades in bonds with 1 to 10 years to maturity	25.98%	26.22%	23.13%
% trades in bonds with more than 10 years to maturity	71.56%	71.01%	74.30%
% trades less than or equal to $100,000	70.43%	74.17%	73.55%
% trades greater than $100,000	29.57%	25.83%	26.45%
% trades of premium bonds	50.91%	48.62%	47.69%
% trades of discount bonds	32.15%	38.70%	36.56%
% trades at par	16.94%	12.68%	15.74%
% trades in Top Five Issuers	86.46%	81.65%	56.75%
% Interdealer Trades	29.49%	28.66%	26.31%
% Dealer Sales	42.15%	46.25%	47.93%
% Dealer Purchases	28.36%	25.09%	25.76%

APPENDIX 2: SUMMARY STATISTICS, BOND LEVEL

Appendix 2: Summary Statistics, Bond Level

Appendix 2 provides summary statistics of all municipal bonds that trade more than nine times each year from 2006 to 2013. The sample of bonds includes 481,365 bonds with 39,105,657 trades. Panel A provides summary statistics for all bonds in the sample, and Panel B provides summary statistics for the top five bond issuing states (California, Texas, New York, Florida, and Pennsylvania). Trade size is the average dollar trade size. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. The return is the percentage abnormal return. The bid-ask spread is the weekly average buy price minus the weekly average selling price. Years to maturity is the number of years until the bond reaches maturity.

	N	Mean	Median
Panel A: All Bonds			
Trade Size	481,365	$333,166.66	$66,954.16
Dollar Volume	481,365	$904,203.53	$180,784.08
Number Trades	481,365	3.00	2.45
Return	481,365	0.0006%	0.0003%
Bid-Ask Spread	481,365	1.45%	1.33%
Years to Maturity	481,365	9.60	8.15
Panel B: Top Five Bond Issuing States			
Trade Size	198,795	$334,022.18	$67,505.44
Dollar Volume	198,795	$901,046.58	$180,652.86
Number of Trades	198,795	2.99	2.45
Return	198,795	0.0007%	0.0003%
Bid-Ask Spread	198,795	1.51%	1.41%
Years to Maturity	198,795	9.94	8.59

APPENDIX 3: EVENT DAY DIFFERENCES

Appendix 3: Event Day Differences

Appendix 3 provides a comparison between event days and non-event days for the sample period 2006 to 2013. Event days are any trading day when an announcement (news, indictment, or trial verdict) is first reported regarding state and government official's misconduct, and non-event days are all other trading days. Trade size is the average dollar trade size. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. The return is the percentage abnormal return. The bid-ask spread is the weekly average buy price minus the weekly average selling price. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	Event Days	Non-Event Days	Difference
Trade Size	$541,793.68	$482,174.88	$59,618.79***
Dollar Volume	$1,474,672.58	$1,356,531.65	$118,140.93**
Number of Trades	3.05	2.96	0.08
Return	0.0002%	0.0004%	-0.0002%
Bid-Ask Spread	1.72%	1.70%	0.02%**

APPENDIX 4: EVENT DAY DIFFERENCES BY EVENT TYPE

Appendix 4: Event Day Differences by Event Type

Appendix 4 provides a comparison between event days and non-event days for the sample period 2006 to 2013. Non-event days are all trading days that are not news, indictment, or trial verdict announcement days. We divide the sample by the types of events. News day is the first day that news of a government officials' misconduct is reported. Indictment days are the days that indictment announcements are made and reported in the press for government officials' misconduct. Trial verdict days are the days that news of the trial's outcome for officials' wrongdoing is reported. Trade size is the average dollar trade size. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. The return is the percentage abnormal return. The bid-ask spread is the weekly average buy price minus the weekly average selling price. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	Event Days	Non-Event Days	Difference
Panel A: News Days			
Return	0.0005%	0.0003%	0.0001%
Trade Size	$663,813.71	$556,349.89	$107,463.82***
Total Trades	2.96	3.01	-0.06
Bid-Ask Spread	1.69%	1.68%	0.01%
Total Dollar Volume	$1,776,256.64	$1,577,230.26	$199,026.38***
Panel B: Indictment Days			
Return	0.0001%	0.0003%	-0.0002%
Trade Size	$485,182.52	$453,294.18	$31,888.34
Total Trades	3.25	3.05	0.20**
Bid-Ask Spread	1.81%	1.78%	0.03%***
Total Dollar Volume	$1,442,277.70	$1,317,453.83	$124,823.87
Panel C: Trial Verdict Days			
Return	0.0004%	0.0004%	0.0000
Trade Size	$465,200.04	$471,257.23	-$6,057.19
Total Trades	3.25	3.19	0.05
Bid-Ask Spread	1.79%	1.75%	0.05%***
Total Dollar Volume	$1,338,582.81	$1,484,612.77	-$146,029.96

APPENDIX 5: TRADE SIZE DIFFERENCES

Appendix 5: Trade Size Differences

Appendix 5 provides a comparison between event days and non-event days and also for trade sizes for the sample period 2006 to 2013. We divide the sample by trade size. Small trades are trades less than $100,000, and large trades are trades greater than $100,000 (Edwards, Harris, and Piwowar, 2007). Event days are any trading day when an announcement (news, indictment, or trial verdict) is first reported regarding state and government official's misconduct, and non-event days are all other trading days. All variables are calculated by trade size. The return is the percentage abnormal return. Trade size is the average dollar trade size. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. The bid-ask spread is the weekly average buy price minus the weekly average selling price. % Trades is the portion of trading for which each trade size accounts. % Volume is the portion of volume for which each trade size accounts. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	Event Days	Non-Event Days	Differences
Panel A: Small Trades			
Return	0.0004%	0.0006%	-0.0002%
Trade Size	$29,965.79	$29,645.95	$319.83**
Dollar Volume	$65,682.67	$62,757.03	$2,925.64**
Bid-Ask Spread	1.98%	1.97%	0.01%
Number of Trades	2.18	2.09	0.10*
% Trades	74.55%	74.29%	0.26%
% Volume	71.47%	71.35%	0.13%
Panel B: Large Trades			
Return	0.0002%	-0.0002%	0.0004%**
Trade Size	$1,408,989.91	$1,293,774.62	$115,215.29**
Dollar Volume	$1,714,352.39	$1,531,802.79	$182,549.60***
Bid-Ask Spread	1.04%	1.00%	0.04%***
Number of Trades	0.82	0.83	-0.01
% Trades	25.44%	25.71%	-0.26%
% Volume	28.53%	28.65%	-0.13%

APPENDIX 6: TRADE SIZE DIFFERENCES BY EVENT TYPE

Appendix 6: Trade Size Differences by Event Type

Appendix 6 provides a comparison between event days and non-event days for the sample period 2006 to 2013. We divide the sample by the types of events. News day is the first day that news of a government officials' misconduct is reported. Indictment days are the days that indictment announcements are made and reported in the press for government officials' misconduct. Trial verdict days are the days that news of the trial's outcome for officials' wrongdoing is reported. Non-event days are all trading days that are not news, indictment, or trial verdict announcement days. The return is the percentage abnormal return. Trade size is the average dollar trade size. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. The bid-ask spread is the weekly average buy price minus the weekly average selling price. % Trades is the portion of trading for which each trade size accounts. % Volume is the portion of volume for which each trade size accounts. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	News Days		Indictment Days		Trial Verdict Days	
	Small Trades	Large Trades	Small Trades	Large Trades	Small Trades	Large Trades
Panel A: Event Days						
Returns	0.0005%	0.0010%	0.0004%	-0.0001%	0.0006%	0.0004%
Trade Size	$30,015.28	$1,714,939.53	$29,798.23	$1,369,842.04	$29,179.48	$1,269,762.89
Dollar Volume	$61,317.11	$2,007,979.07	$72,435.66	$1,670,680.44	$68,819.92	$1,565,566.54
Bid-Ask Spread	2.00%	0.94%	2.05%	1.10%	2.07%	1.02%
Number of Trades	2.04	0.89	2.39	0.83	2.36	0.84
% Trades	72.35%	27.65%	76.32%	23.68%	75.03%	24.97%
% Volume	69.20%	30.81%	72.78%	27.22%	71.74%	28.26%
Panel B: Non-Event Days						
Returns	0.0006%	-0.0001%	0.0005%	-0.0003%	0.0006%	0.0001%
Trade Size	$29,743.80	$1,514,466.32	$29,473.63	$1,251,898.31	$29,049.63	$1,417,612.31
Dollar Volume	$62,763.94	$1,696,252.61	$65,555.51	$1,543,255.90	$67,000.46	$1,607,264.27
Bid-Ask Spread	1.99%	0.95%	2.04%	1.04%	2.03%	0.95%
Number of Trades	2.07	0.91	2.18	0.82	2.27	0.89
% Trades	72.40%	27.60%	75.56%	24.44%	74.86%	25.14%
% Volume	69.28%	30.72%	72.42%	27.58%	71.64%	28.36%
Panel C: Differences						
Returns	-0.0001%	0.0012%***	-0.0001%	-0.0002	0.0000%	0.0003%
Trade Size	$271.48	$200,473.21***	$324.60	$117,943.73	$129.85	-$147,849.42
Dollar Volume	-$1,446.83	$311,726.45***	$6,880.15***	$127,424.53	$1,819.47	-$41,697.74
Bid-Ask Spread	0.01%	-0.01%	0.02%	0.06%***	0.04%**	0.07%***
Number of Trades	-0.03	-0.02	0.20***	0.01	0.10	-0.05
% Trades	-0.06%	0.06%	0.76%**	-0.76%**	0.17%	-0.17%
% Volume	-0.09%	0.09%	0.36%	-0.36%**	0.09%	-0.09%

APPENDIX 7: SPREAD REGRESSIONS

Appendix 7: Spread Regressions

Appendix 7 provides spread regression estimations for 481,365 municipal bonds with 39,105,657 trades from 2006 to 2013. The bid-ask spread is the weekly average buy price minus the weekly average selling price. Model 1 includes all events. Event days are any trading day when an announcement (news, indictment, or trial verdict) is first reported regarding state and government official's misconduct, and non-event days are all other trading days. Model 2 provides results for news days. Model 3 provides estimations for indictment announcement days. Model 4 provides regression estimates for trial verdict announcement days. News day is the first day that news of a government officials' misconduct is reported. Indictment days are the days that indictment announcements are made and reported in the press for government officials' misconduct. Trial verdict days are the days that news of the trial's outcome for officials' wrongdoing is reported. Event day is equal to one on the day of an event relating to government officials' misconduct and zero otherwise. Post-Event Days is equal to one the five days following the event and zero otherwise. Govt Official Convictions is the previous year's government officials' convictions (by the justice department) for each state. Dollar volume is the average daily bond trading volume, and the number of trades is the average times a bond trades each day. Trade size is the average dollar trade size. Volatility is calculated following Downing and Zhang (2004): $\frac{100}{\text{Price}_t}\left(\text{Price}_t^{\text{Max}} - \text{Price}_t^{\text{Min}}\right)$. Years to maturity is the time until a bond reaches maturity. Revenue Bond is equal to one if the bond is a revenue bond and zero otherwise. Taxable is equal to one if the bond is a taxable bond and zero otherwise. Top Five Issuer is equal to one if the bond is issued by California, Texas, New York, Florida, or Pennsylvania. Median income is the average median income of households in each state. General Fund Revenue is the revenue earned by each state's general fund. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	All Events	News Events	Indictment Events	Trial Verdict Events
Intercept	0.6336***	0.6338***	0.6341***	0.6340***
	(23.97)	(24.00)	(24.08)	(24.02)
Variables of Interest				
Event Day	0.0557***	0.0434***	0.0356***	0.1288***
	(15.17)	(7.33)	(6.41)	(15.11)
Post-Event Days [+1,+5]	0.0480***	0.0548***	0.0276***	0.0737***
	(22.27)	(17.13)	(7.97)	(14.12)
Govt Official Convictions	-0.0004***	-0.0004***	-0.0004***	-0.0004***
	(-44.32)	(-44.13)	(-44.55)	(-45.11)
Bond/Trading Traits				
Dollar Volume	0.0000***	0.0000***	0.0000***	0.0000***
	(55.84)	(55.82)	(55.81)	(55.81)
Number of Trades	-0.0003***	-0.0003***	-0.0003***	-0.0003***
	(-14.15)	(-14.61)	(-14.61)	(-14.61)
Trade Size	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-11.68)	(-11.68)	(-11.68)	(11.68)
Volatility	0.4179***	0.4179***	0.4179***	0.4179***
	(50.93)	(51.92)	(56.30)	(56.29)
Years to Maturity	0.0017***	0.0017***	0.0017***	0.0017***
	(16.49)	(16.48)	(16.48)	(16.48)
Revenue Bond	-0.0004	-0.0004	-0.0004	-0.0004

	(-0.97)	(-0.93)	(-0.94)	(-0.88)
Taxable	-0.1065***	-0.1065***	-0.1065***	-0.1065***
	(-12.76)	(-12.76)	(-12.76)	(-12.73)
Top 5 Issuer	0.0403***	0.0404***	0.0404***	0.0406***
	(3.18)	(3.34)	(3.30)	(3.58)
State Characteristics				
Median Income	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-5.50)	(-5.59)	(-5.81)	(-5.76)
General Fund Revenue	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-13.85)	(-13.76)	(-13.70)	(-13.67)
R-Squared	51.37%	51.37%	51.37%	51.37%

APPENDIX 8: SMALL VERSUS LARGE DOLLAR VOLUME

Appendix 8: Small versus Large Dollar Volume

Appendix 8 provides volume regression estimations for 481,365 municipal bonds with 39,105,657 trades from 2006 to 2013. The dependent variable is the small trade (large trade) dollar volume for each day. News day is the first day that news of a government officials' misconduct is reported. Indictment days are the days that indictment announcements are made and reported in the press for government officials' misconduct. Trial verdict days are the days that news of the trial's outcome for officials' wrongdoing is reported. Event day is equal to one on the day of an event relating to government officials' misconduct and zero otherwise. Post-Event Days is equal to one the five days following the event and zero otherwise. Govt Official Convictions is the previous year's government officials' convictions (by the justice department) for each state. Years to maturity is the time until a bond reaches maturity. Revenue Bond is equal to one if the bond is a revenue bond and zero otherwise. Taxable is equal to one if the bond is a taxable bond and zero otherwise. Top Five Issuer is equal to one if the bond is issued by California, Texas, New York, Florida, or Pennsylvania. Population is the annual Census Bureau estimate of population for each state. Median income is the average median income of households in each state. General Fund Revenue is the revenue earned by each state's general fund. Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	News Days		Indictment Days		Verdict Days	
	Small $ Volume	Large $ Volume	Small $ Volume	Large $ Volume	Small $ Volume	Large $ Volume
Intercept	-485,902***	-27,103,649***	-490,781***	-27,405,503***	-491,316***	-27,445,983***
	(-9.36)	(-11.11)	(-9.98)	(-11.01)	(-9.90)	(-11.14)
Variables of Interest						
Event Day	-1,225,336***	-64,544,254***	-694,864***	-49,443,823***	-145,815***	-20,652,997***
	(-15.40)	(-13.86)	(-6.53)	(-11.81)	(-4.99)	(-3.74)
Post-Event Days	-965,271***	-62,717,128***	-725,653***	-47,725,148***	-484,395***	-22,767,430***
[+1,+5]	(-11.86)	(-17.78)	(-10.54)	(-16.16)	(-7.72)	(-6.48)
		-905,295***	-14,955***	-901,147***	-14,909***	-898,123***
Govt Convictions	-15,024***	(-20.20)	(-18.28)	(-20.21)	(-18.27)	(-20.19)
	(-18.29)					
Bond/Trading Traits		-2,953,711***	-36,707***	-2,954,631***	-36,701***	-2,954,175***
Years to Maturity	-36,692***	(-19.71)	(-12.93)	(-19.71)	(-12.93)	(-19.71)
	(-12.93)	98,189,160***	1,688,683***	98,203,433***	1,688,437***	98,185,736***
Revenue Bond	1,688,456***	(22.29)	(20.91)	(22.12)	(20.19)	(22.13)
	(20.19)	2,779,571***	102,959***	2,754,750***	103,399***	2,784,720***
Taxable	103,302***	(35.32)	(6.83)	(34.99)	(6.86)	(35.40)
	(6.85)	-34,951,779***	-618,457***	-34,887,812***	-619,858***	-34,985,314***
Top 5 Issuer	-619,466***	(-20.40)	(-18.68)	(-20.23)	(-18.68)	(-20.24)
	(-18.68)					
State Characteristics		7.5990**	0.1436*	7.5990**	0.1430*	7.5877**
Population	0.1436*	(2.06)	(1.91)	(2.06)	(1.91)	(2.16)
	(1.90)	796.3939***	14.5790	803.4074***	14.5667	803.2922***
Median Income	14.4560	(14.47)	(1.21)	(14.18)	(1.21)	(14.11)
	(1.21)	-759.7013***	-18.9345***	-768.0565***	-18.9219***	-767.2752***

General Fund Revenue	-18.8018***	(-13.95)	(-16.21)	(-14.04)	(-16.20)	(-14.03)
	(-16.18)	25.20%	11.30%	25.20%	11.30%	25.20%
R-Squared	11.30%					

APPENDIX 9: WEIGHTED PRICE CONTRIBUTION FOR EVENT AND NON-EVENT DAYS

Appendix 9: Weighted Price Contribution for Event and Non-Event Days

Appendix 9 provides estimations of weighted price contribution for small trades, large trades, and trade types (dealer purchases, dealer sales, and interdealer trades) on event days and non-event days. Small trades are less than $100,000, and large trades are greater than $100,000 (Edwards, Harris, and Piwowar, 2007). Event days are any trading day when an announcement (news, indictment, or trial verdict) is first reported regarding state and government official's misconduct, and non-event days are all other trading days. We calculate weighted price contribution following Barclay and Warner (1993). Significance at the 1%, 5%, and 10% is indicated by ***, **, and *.

	Event Days	Non-Event Days	Difference
Panel A: Trade Sizes			
Small Trades	39%	58%	19%***
Large Trades	61%	42%	19%***
All Trades	100%	100%	
Panel B: Trader Types			
Dealer Purchases	53%	35%	18%***
Dealer Sales	35%	49%	14%***
Interdealer Trades	12%	16%	-4%***
All Trades	100%	100%	

FIGURES

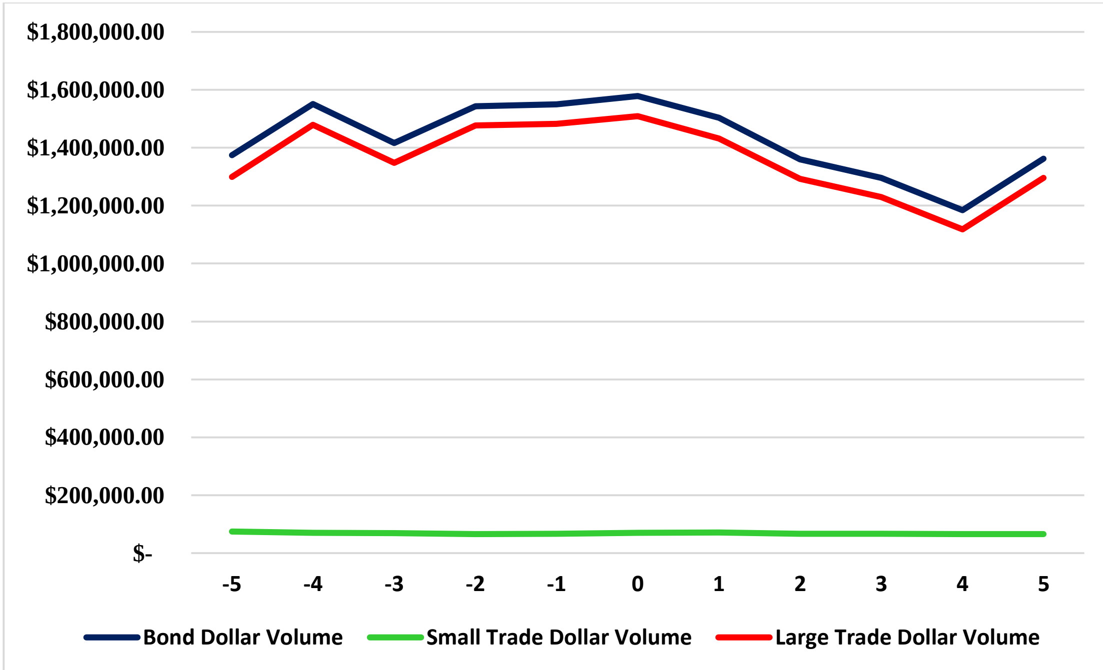

Figure 1. Average Municipal Bond Dollar Volume Before, During, and After Wrongdoing Events.

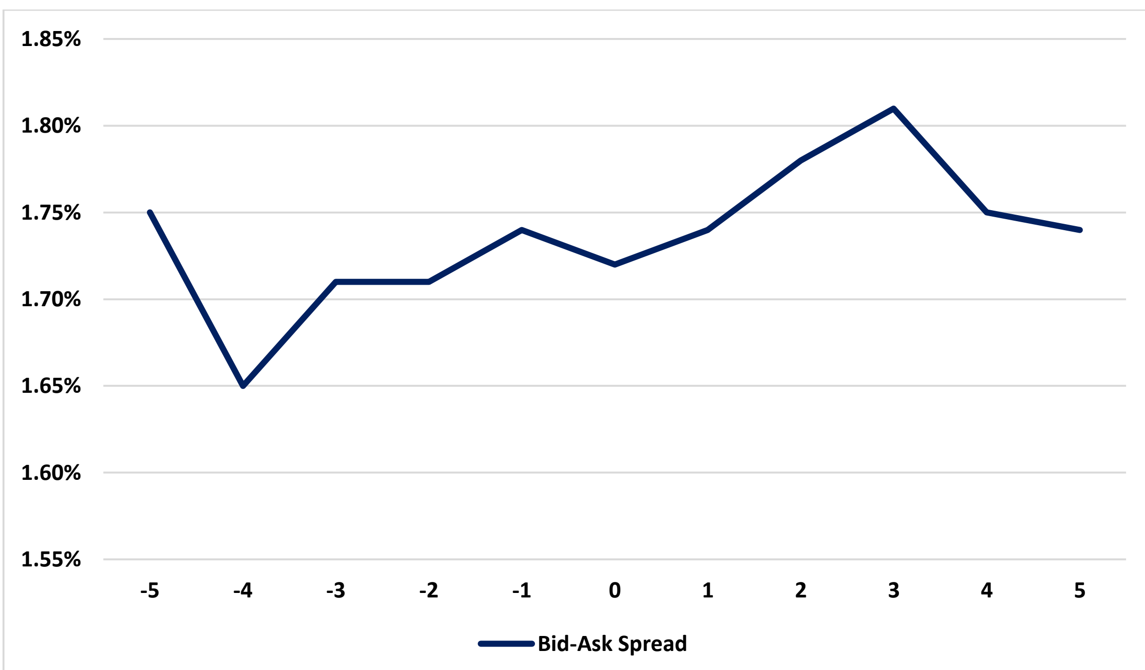

Figure 2. Average Municipal Bond Bid-Ask Spreads Before, During, and After Wrongdoing **Events.**

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